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ABSTRACT

This handbook contains journal articles, reports, and documents collected for the purpose of providing school administrators with current information on computer applications in public schools. The first part of the handbook includes reports on computer oriented programs in the schools of Alaska and Oregon, procedures for assessing computer needs, recommendations for evaluating and purchasing computer hardware, and some model applications of computers for teaching the handicapped and/or in basic skills programs. The second part provides profiles of schools and school districts currently using microcomputers as part of their instructional program. Each profile presents a description of a specific computer project, including hardware, software, personnel, costs and a contact person and phone number for arranging on-site visits. Additional sources of information on computer applications in educational settings are identified in bibliographies accompanying many of the reports and in a resource list at the end of the handbook. (MER)

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MICROCOMPUTERS IN TODAY'S SCHOOLS

An Administrators' Handbook

Produced for
the
Conference on Microcomputers in Today's Schools

November 11-12, 1981
Portland, Oregon

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Articles

MICROCOMPUTERS IN TODAY'S SCHOOLS: ARTICLES

The following collection of journal articles, reports and documents is designed to provide background information for those persons interested in educational applications of microcomputers. Additional sources of information are identified in bibliographies accompanying many of the reports and in the Resource List included in this Handbook

COMPUTER-ASSISTED INSTRUCTION

Topic Summary Report
by
P. Rapaport and W. G. Savard

December 1980

Prepared for the Alaska Department of Education
Office of Planning and Research
Research on School Effectiveness Project

Developed by Audit and Evaluation Program
Northwest Regional Educational Laboratory
for the
Alaska Department of Education
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PREFACE

This report is one of several in a series of reviews of research literature conducted for the Alaska School Effectiveness Project. Each of the reports addresses a topic which is deemed to have an impact, actual or potential, on school effectiveness. All of the reports have been generated using the same general approach and a common reporting format.

The review process begins with a topical literature search using both computer based ERIC and conventional library methods. Articles and other documents found are analyzed and abstracted into a brief form called an Item Report. Each of the items is then judged against a set of pre-established criteria and ranked on a five-point scale. The collection of Item Reports are then examined for purposes of identifying issues. These issues are stated in the form of hypotheses. Each hypothesis thus generated becomes the subject of a Decision Display. A Decision Display is created by sorting the Item Reports into those which support or negate the hypothesis, are inconclusive, are badly flawed, or are irrelevant. One or more Decision Displays are generated for each topic addressed. A Summary Report is then generated from the consideration of the Decision Displays and the file of Item Reports. Thus, each complete report in the series consists of a Summary Report which is backed up by one or more Decision Displays which in turn are supported by a file of Item Reports. This format was designed to accommodate those readers who might wish to delve into various depths of detail.

This report is not intended to represent the "final word" on the topic considered. Rather, it represents the analysis of a particular collection of research documents at this time. There may be other documents that were not found because of time or other limitations. There may be new research published tomorrow. This present report represents our best judgment of available information at this time. This format allows for modification and re-analysis as new information becomes available or old information is re-interpreted.

For a more complete description of the analysis process see William G. Savard, Procedures for Research on School Effectiveness Project, Northwest Regional Educational Laboratory, December 10, 1980.

Topic: Computer-Assisted Instruction
Authors: P. Rapaport/W. G. Savard
Date: December 12, 1980

Overview

Educators have recently begun to examine computer-assisted instruction (CAI) more closely, due to the recent slashing of computer costs caused by the technological advances which produced the mini- and micro-computer. These technological advances have rendered obsolete CAI cost information which is over two years old. Micro-computers with enough power to provide CAI practice, problem solving and simulation are now quite inexpensive, some costing less than $2,000. Over a four-year period, such a system could cost less than $1 per student hour, including courseware, thus making CAI increasingly attractive from the financial point of view. There are also new levels of convenience. When CAI was first tried on a large scale, the it was necessary to bring the students to the computer terminals. The present state of the art brings the computer to the student and requires no communication costs, no special operating personnel and little or no modification of facilities. The basic remaining question then is, how well does it work in promoting student learning?

Major Findings

Achievement. The studies covered in this report are generally well-designed and show remarkable consistency in their findings. Almost every study finds that traditional instruction, supplemented by CAI, leads to higher achievement than traditional instruction alone. Two of the three reviews which are included in this report failed to report a single case of contradictory findings. Even the extensive review by Thomas (1979) could only uncover one secondary typing course, one college accounting class and one community college course where traditional instruction was found to be superior. All the elementary studies, and virtually all the secondary studies report achievement gains by the students receiving CAI.

Studies of CAI as a replacement for traditional instruction are not as conclusive. Most of the studies reviewed by Edwards and her colleagues (1975) do not find CAI alone superior to traditional instruction alone. However, nearly half of those studies do find higher achievement in the CAI group.

A very few of the studies reported differences in the effectiveness of CAI based upon characteristics of the students. Three studies report that CAI is more effective for low ability students than for high ability students. Two other studies report that boys benefit from CAI more than girls do, but one study fails to find any differences. However, both of these findings may be caused by a ceiling effect; in both cases, the groups which improved the most had the most room to improve.

Attitude. Most studies find that CAI students have a better attitude toward the subject matter than students who received traditional instruction alone. Many studies do not find a difference in attitude, and Thomas's review found one study with more negative attitudes in the CAI study. This was in the same community college study which found less achievement in one of the CAI groups. The usual finding is that students have a very positive and enthusiastic response to the CAI course.

Other Findings. All of the studies which reported the amount of time taken by students to learn the material found that, compared with traditionally instructed students, CAI students complete the same material in2less time or more material in the same time. There is no consistent evidence that there is any difference in the retention rates of CAI and traditionally instructed students. Thomas (1979) reviewed three studies which show that students can be assigned to share terminals and still achieve as much as students assigned to individual terminals.

Conclusions

The research findings make it clear that CAI is an effective supplement to traditional instruction. The evidence is not strong enough to support teaching by CAI exclusively; a combination approach seems to work best. Computer-assisted instruction is also popular with students and often improves their attitude toward the subject matter. The CAI approach usually results in the students learning more material in a given time period, or the same amount of material in less time. Fears that students would forget CAI learned material more easily than traditionally learned materials appear to be unfounded although findings in this area are mixed or inconclusive.

Recommendations

It is recommended that the use of computer-assisted instruction be actively promoted and expanded. This would be especially important for small schools in rural areas where it is difficult to offer full schedules of classes to limited numbers of students. It is also recommended that the use of computer-assisted instruction be increased with low-achieving students and with students who tend to be alienated by traditional teaching methods.

It is recognized that the development of CAI programs may be beyond the capabilities of some small districts. It is therefore recommended that the state take a leadership role in such development efforts, providing both financial support and technical expertise.

COMPUTER-ASSISTED INSTRUCTION
Decision Display
#1

Restatement of issue as a hypothesis:

Computer-Assisted Instruction, when combined with traditional instruction, leads to higher achievement than traditional instruction alone.

Item Number	Short Title	Quality Rating of Study [ ]	
Items which tend to support hypothesis:			
6	Edwards, *et al.*, 1975, CAI Review	[4]	(All studies support)
60	Fletcher & Atkinson, 1972, Stanford CAI	[4]	
20	Modisett, 1980, CAI, Remedial Math	[4]	
59	Thomas, 1979, CAI review	[4]	(52 studies support)
26	Vincent, 1977, CAI, Special Education	[4]	
8	Wilson, 1980, CAI Review	[4]	(19 studies support)
35	Leunetta & Blick, 1973, CAI, Physics	[3]	
21	Litman, 1977, CAI, Reading	[3]	
19	Pachter, 1979, CAI, Math	[3]	
3	Ragosta, *et al.*, 1980, CAI Longitudinal Study	[3]	
17	Wilkinson, 1979, CAI, PLAN	[3]	
13	Wilson & Fitzgibbon, 1970, CAI, English	[3]	
22	Haberman, 1977, CAI, Disturbed Children	[2]	
Items which tend to deny hypothesis:			
59	Thomas, 1979, CAI Review	[4]	(3 studies deny)
Items which are inconclusive regarding the hypothesis:			
59	Thomas, 1979, CAI Review	[4]	(4 studies inconclusive)
8	Wilson, 1980, CAI Review	[4]	(2 studies inconclusive)
Items which were excluded because they were weak:			
25	Annelli, 1977, CAI Reading	[1]	
5	Menis, *et al.*, 1980, CAI, Algebra	[1]	

Items which were excluded because they were judged to be irrelevant to this hypothesis:

7	Martin, 1973, CAI, Drill and Practice	[3]
16	Cassie, 1977, CAI, Career Education	[2]
18	Schaeffer, 1979, CAI, College German Drill Practice	
23	Drake, 1978, CAI, Guidance	[2]
24	Beck, 1979, CAI, Student Attitude	
61	Beck, 1979, CAI, Attitude	
62	Suppes, *et al.*, 1968, CAI, Arithmetic	

COMPUTER-ASSISTED INSTRUCTION
Decision Display
#2

Restatement of issue as a hypothesis:

CAI alone leads to higher achievement than traditional instruction alone.

Item Number	Short Title	Quality Rating of Study [ ]
	Items which tend to support hypothesis:	
6	Edwards, et al., 1975, CAI Review	[4] (9 studies support)
	Items which tend to deny hypothesis:	
	None	
	Items which are inconclusive regarding the hypothesis:	
6	Edwards, et al., 1975, CAI Review	[4] (11 studies inconclusive)
	Items which were excluded because they were weak:	
	None	
	Items which were excluded because they were judged to be irrelevant to this hypothesis:	
60	Fletcher & Atkinson, 1972, Stanford CAI	[4]
20	Modisett, 1980, CAI, Remedial Math	[4]
59	Thomas, 1979, CAI Review	[4]
26	Vincent, 1977, CAI, Special Education	[4]
8	Wilson, 1980, CAI Review	[4]
35	Leunetta & Blick, 1973, CAI, Physics	[3]
21	Litman, 1977, CAI, Reading	[3]
19	Pachter, 1979, CAI, Math	[3]
3	Ragosta, et al., 1980, CAI Longitudinal Study	[3]

Items which were excluded because they were judged to be irrelevant to this hypothesis: (Continued)

17	Wilkinson, 1979, CAI, PLAN	[3]
13	Wilson & Fitzgibbon, 1970, CAI, English	[3]
25	Annelli, 1977, CAI, Reading	[1]
5	Menis, *et al.*, 1960, CAI, Algebra	[1]
16	Cassie, 1977, CAI, Career Education	[2]
18	Schaeffer, 1979, CAI, College German Drill Practice	
23	Drake, 1978, CAI, Guidance	[2]
24	Beck, 1979, CAI, Student Attitudes	
61	Beck, 1979, CAI, Attitude	
62	Suppes, *et al.*, 1968, CAI, Arithmetic	

COMPUTER-ASSISTED INSTRUCTION
Decision Display
#3

Restatement of issue as a hypothesis:

Computer-Assisted Instruction leads to better attitudes toward the subject matter than are found in students receiving traditional instruction.

Item Number	Short Title	Quality Rating of Study [ ]	
Items which tend to support hypothesis:			
59	Thomas, 1979, CAI Review	[4]	(10 studies support)
26	Vincent, 1977, CAI, Special Education	[4]	
8	Wilson, 1980, CAI Review	[4]	(21 studies support)
19	Pachter, 1979, CAI, Math	[3]	
Items which tend to deny hypothesis:			
59	Thomas, 1979, CAI Review	[4]	(1 study deny)
Items which are inconclusive regarding the hypothesis:			
59	Thomas, 1979, CAI Review	[4]	(7 studies inconclusive)
8	Wilson, 1980, CAI Review	[4]	(21 studies inconclusive)
35	Leunetta & Blick, 1973, CAI, Physics	[3]	
Items which were excluded because they were weak:			
	None		
Items which were excluded because they were judged to be irrelevant to this hypothesis:			
6	Edwards, *et al.*, 1975, CAI Review	[4]	
60	Fletcher & Atkinson, 1972, Stanford CAI	[4]	
20	Modisett, 1980, CAI, Remedial Math	[4]	
21	Litman, 1977, CAI, Reading	[3]	
7	Martin, 1973, CAI, Drill and Practice	[3]	
3	Ragosta, *et al.*, 1980, CAI, Longitudinal Study	[3]	

Items which were excluded because they were judged to be irrelevant to this hypothesis: (Continued)

17	Wilkinson, 1979, CAI, PLAN	[3]
13	Wilson & Fitzgibbon, 1970, CAI, English	[3]
25	Annelli, 1977, CAI, Reading	[1]
5	Menis, et al., 1980, CAI, Algebra	[1]
16	Cassie, 1977, CAI, Career Education	[2]
18	Schaeffer, 1979, CAI, College German Drill Practice	
23	Drake, 1978, CAI, Guidance	[2]
24	Beck, 1979, CAI, Student Attitude	
61	Beck, 1979, CAI, Attitude	
62	Suppes, et al., 1968, CAI, Arithmetic	

COMPUTER-ASSISTED INSTRUCTION
Decision Display
#4

Restatement of issue as a hypothesis:

Students receiving CAI complete the same materials as traditionally instructed students in less time, or they complete more material in the same time.

Items which tend to support hypothesis:

Item Number	Short Title	Quality Rating of Study [ ]
6	Edwards, et al., 1975, CAI Review	[4] (9 studies support)
59	Thomas, 1979, CAI Review	[4] (10 studies support)
8	Wilson, 1980, CAI Review	[4] (2 studies support)

Items which tend to deny hypothesis:

None

Items which are inconclusive regarding the hypothesis:

None

Items which were excluded because they were weak:

None

Items which were excluded because they were judged to be irrelevant to this hypothesis:

Item Number	Short Title	Quality Rating of Study [ ]
60	Fletcher & Atkinson, 1972, Stanford CAI	[4]
20	Modisett, 1980, CAI, Remedial Math	[4]
26	Vincent, 1977, CAI, Special Education	[4]
35	Leunetta & Blick, 1973, CAI, Physics	[3]
21	Litman, 1977, CAI, Reading	[3]
7	Martin, 1973, CAI, Drill and Practice	[3]
19	Pachter, 1979, CAI, Math	[3]
3	Ragosta, et al., 1980, CAI Longitudinal Study	[3]

Items which were excluded because they were judged to be irrelevant to this hypothesis: (Continued)

17	Wilkinson, 1979, CAI, PLAN	[3]
13	Wilson & Fitzgibbon, 1970, CAI, English	[3]
25	Annelli, 1977, CAI, Reading	[1]
5	Menis, *et al.*, 1980, CAI, Algebra	[1]
16	Cassie, 1977, CAI, Career Education	[2]
18	Schaeffer, 1979, CAI, College German Drill Practice	
23	Drake, 1978, CAI, Guidance	[2]
24	Beck, 1979, CAI, Student Attitude	
61	Beck, 1979, CAI, Attitude	
62	Suppes, *et al.*, 1968, CAI, Arithmetic	

COMPUTER-ASSISTED INSTRUCTION
Decision Display
#5

Restatement of issue as a hypothesis:

CAI students forget the material they have learned over long periods more than traditionally instructed students forget.

Item Number	Short Title	Quality Rating of Study [ ]	
Items which tend to support hypothesis:			
6	Edwards, et al., 1975, CAI Review	[4]	(9 studies support)
8	Wilson, 1980, CAI Review	[4]	(2 studies support)
Items which tend to deny hypothesis:			
8	Wilson, 1980, CAI Review	[4]	(2 studies deny)
Items which are inconclusive regarding the hypothesis:			
6	Edwards, et al., 1975, CAI Review	[4]	(9 studies inconclusive)
59	Thomas, 1979, CAI Review	[4]	(10 studies inconclusive)
8	Wilson, 1980, CAI Review	[4]	(2 studies inconclusive)
35	Leunetta & Blick, 1973, CAI, Physics	[3]	
Items which were excluded because they were weak:			
	None		
Items which were excluded because they were judged to be irrelevant to this question:			
60	Fletcher & Atkinson, 1972, Stanford CAI	[4]	
20	Modisett, 1980, CAI, Remedial Math	[4]	
26	Vincent, 1977, CAI, Special Education	[4]	
21	Litman, 1977, CAI, Reading	[3]	
7	Martin, 1973, CAI, Drill and Practice	[3]	
19	Pachter, 1979, CAI, Math	[3]	
3	Ragosta, et al., 1980, CAI Longitudinal Study	[3]	

__Items which were excluded because they were judged to be irrelevant to this hypothesis:__ (Continued)

17	Wilkinson, 1979, CAI, PLAN	[3]
13	Wilson & Fitzgibbon, 1970, CAI, English	[3]
25	Annelli, 1977, CAI, Reading	[1]
5	Menis, _et al_., 1980, CAI, Algebra	[1]
16	Cassie, 1977, CAI, Career Education	[2]
18	Schaeffer, 1979, CAI, College German Drill Practice	
23	Drake, 1978, CAI, Guidance	[2]
24	Beck, 1979, CAI, Student Attitude	
61	Beck, 1979, CAI, Attitude	
62	Suppes, _et al_., 1968, CAI, Arithmetic	

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INSTRUCTIONAL COMPUTING:

Survey and Recommendations

Prepared by

Computer Technology Program
Northwest Regional Educational Laboratory

October 1981

These reports are derived from a study done for the Portland Public Schools (Portland, Oregon) by the Computer Technology Program, Northwest Regional Educational Laboratory, December 1980. Used by permission.

The Demand for Instructional Computing: Societal and Educational

The June 30, 1980 issue of Newsweek introduced its seven-page feature article on computer technology with these words:

> A revolution is underway. Most Americans are already well aware of the gee-whiz gadgetry that is emerging, in rapidly accelerating bursts, from the world's high-technology laboratories. But most of us perceive only dimly how pervasive and profound the changes of the next twenty years will be. We are at the dawn of the era of the smart machine--an "information age" that will change forever the way an entire nation works, plays, travels and even thinks.... Even computer scientists, who best understand the galloping technology and its potential, are wonderstruck by its implications....
>
> (And)
>
> The explosion is just beginning....(1)

Computers have already taken their place in the everyday lives of Americans in all sectors of our society. Behind the scenes, computers are a part of automobiles, TVs, toys, microwave ovens, electronic games, and home security systems, as well as police surveillance systems, banking and billing systems and so forth. On center stage computers confront many Americans through computerized home-entertainment systems, and everyday we run into more and more computer terminals checking out our groceries or other purchases at stores, checking out our books at the library, or checking our pulse and heart rate during our routine physical examinations at the doctor's office. With the advent of affordable desk-top microcomputers in the last years of the 1970's, the versatile, challenging, intriguing and useful microcomputer itself is becoming an increasingly common feature in American homes.

Not only is the assurance given in the June, 1979 issue of American Education obviously true: "Like television, computers are here to stay,"(2) but, the vision of Dr. Seymour Papeat of M.I.T. during

Congressional Hearings in 1977 characterizes clearly the place computers are taking in our lives:

> During the nineteen eighties small but immensely powerful personal computers will become as much a part of everyone's life as the TV, the telephone, the printed paper and the notebook. Indeed computers will integrate and supercede the functions of these and other communicational and recreational home technologies.(3)

The predicted omnipresence of computers casually in our daily lives takes a back seat only to the spectacle of a related development: our industrial society is rapidly becoming predominantly an "information society" in which, today,

> science-based information industries account for more than one-half of our gross-national-product (GNP) and over half of all our jobs. The professional and technical segment is one of the fastest growing employment sectors in our work force. Computers have become a critical and indispensable part of this development.(4)

As a result of these progressive developments in our society, educators in America today are recognizing the importance of computer literacy on the part of the populace.

> It is important for all citizens to understand what computers can and cannot do. Students should be aware of the many uses of computers in society, such as their use in teaching/learning, financial transactions and information storage and retrieval. The "mystique" surrounding computers is disturbing and can put persons with no understanding of computers at a disadvantage. The increasing use of computers by government, industry and business demands an awareness of computer uses and limitations.(5)

Further, as one of education's central aims is to prepare students to take their places as productive, contributing citizens, the question asked by Dr. F. James Rutherford of the National Science Foundation in 1979 is one with which all responsible educators are coming to grips:

> How will students denied access to computer-related skills fare in the competition for jobs and advanced academic training in an information society?(6)

The impetus to incorporate computers into the curriculum has come to education, however, not only from the developments in the society which it serves, but from within its own precincts. American education has been characterized as developing in three phases. The first may be typified as the early commitment to universality of educational privileges, which shaped and has been shaped by media (lecture-technique, textbooks, films and recordings) suited to instruction of large numbers of students. In the last two decades, emphasis moved to equality of universal education, with attention centering on segments of the student population in need of special instructional methods and modes: the underprivileged (largely minority children), underachievers, the gifted and the handicapped. In the last decade, the focus has broadened (or deepened) to concern for the quality of education, with attendant emphasis on individual needs, significant achievement and overall accountability.(7)

In pursuit of the goals and solutions to the problems addressed in each phase, education has progressively adapted and expanded its methods and media. In the recent two decades, diversification and individualization of instruction have joined with accountability and relevancy as focuses of modification of instructional methods. During this period, computers have, of course, been introduced into the curriculum in the form of classes in programming and data processing techniques where appropriate. Further, however, computers have been the center of a growing tide of interest due to their versatility and potential power in direct instruction, as well as to their relevancy and interest to students as modern mechanisms which can be controlled, manipulated, and interacted with personally or in groups with considerable satisfaction. As Dr. Richard Otte of the National Institute of Education pointed out in 1978, the fundamental goal of universality in education can be served well by computers in instruction as they provide

> a variety of instructional strategies and delivery modes, and can be a useful and exciting means for expanding learning opportunities.(8)

In particular, educational professionals have been researching and analysing the effectiveness of computers in the areas central to the concern for educational equality and quality: the underpriveleged, underachieving, gifted, and handicapped students and the basic skills. Dr. Sylvia Charp of the Philadelphia School District expresses the characteristic improvement in participation by the disadvantaged:

> ...many "reluctant learners" who are involved in computer supported progams begin to lose their hesitancy, respond, and become more active and interested learners.(9)

Dr. Dorothy A. Sisk, Director of the Office of the Gifted, U.S. Office of Education, explained the success of computers in instruction for the gifted as centering on two roles: first, the computer can serve as a comprehensive in-depth information source in the classroom for the gifted, and can provide a new and challenging vehicle for expressing their ideas. In summary, Dr. Sisk suggested:

> ...the computer can serve as a means for gifted students to acquire information at the rapid pace they are capable of learning and acquire the use of the computer as a viable and necessary skill for the coming age of technology.(10)

For the special group of students technically considered handicapped? The American Education Journal described a few of the advances in the technology which allow blind students to read through print-to-English conversion mechanisms, deaf or palsied students to communicate over distances through typed messages on terminal screens, and concluded:

> The value of computers in education for the handicapped in incalculable.(11)

And basic skills! Since the mid-1960's, the national levels of achievement of basic skills has been declining as expressed by SAT scores. The tasks of reversing the trend have promoted much of the research into the effectiveness of computers not only in providing instruction through computer-based drill and practice but in carrying out efficient tracking and individualization of instruction which an unaided teacher with a class of 25-30 students cannot hope to perform extensively. The research altogether has shown the patient/attentive/ responsive computer to be an effective drill master for students in basic and remedial instruction. As the California State Department of Education reported in 1977, "The results from many years of careful research and development in CAI are very positive as to its effectiveness as a learning tool."(12)

And reporting to the Congressional Hearing assembly in 1979 on "Information and Communications Technologies Appropriate in Education," Dr. Nellouise Watkins of Bennett College articulated the concern over basic skills and the implicit need for the efficient individualization of instruction. In her words, "Research has shown the task can be accomplished with the computer."(13)

In summary, the prospects of computers joined with traditional instructional methods to further the aims of equality and quality of education appear to be excellent.

Schools across the nation have been responding to the developing societal and educational demands for computers in the schools as funds, expertise, and understanding have allowed. The State of Oregon has been among the leaders in educational computing during the last decade, with the establishment of the Oregon Council for Computers in Education (which has now become the International Council on Computers in Education), and with the publication of the teacher-oriented instructional computing magazine The Oregon Computing Teacher (which has become The Computing Teacher with a national subscription list).

Oregon educators have given consistent attention to the expansion of computer technology within their school districts and through the efforts of the Council on Computers in Education have established a program of instructional computing. Thus, they find themselves in an advantageous position at the beginning of the 1980's to make increasingly effective use of computers in achieving the goals of equality and quality in education, as well as in better preparing students to take their places as confident computer-literate producers and citizens in the information society dawning around us.

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A Survey of Research

Because of the implications for actual teaching tasks of classroom teachers, there is great interest in the effectiveness of methods of "Teaching With Computers." We have therefore focused on that category in this review, conducted in August and September 1980, of research on the effectiveness of computer assisted instruction (CAI) as compared to other forms of instruction. CAI is generally characterized by the interaction of a student at a computer terminal with instructional material (a question, a paragraph, a number, etc.) presented by the computer system. The student responds by typing an answer or command and the computer responds with additional instructional stimuli which may be some function of the student's previous response. For purposes of this literature search, CAI includes drill, practice, tutorial, problem solving, and simulation, which are defined as follows:

- drill--student responds quickly to brief items or questions, much like traditional "flash cards";
- practice--student answers more complex questions which may require more extensive interaction with the computer;
- tutorial--textual materials and questions are presented to the student, and frequently uses branching based upon the student's response;
- simulation--models a portion of reality and allows the student to experience the interaction of complex events;
- problem solving--student applies principles and rules to various situations.

Studies included in this report are primarily limited to elementary and secondary education, but basic skills applications of CAI in higher education are also included because of their relevance for younger students who have not arrived at the needed level of competency.

This review of research will present evidence relative to the effectiveness of CAI on student achievement, motivation and attitude toward CAI, retention of material, comparisons of time to learn subject matter, and teacher-student interaction.

Computer-managed instruction (CMI) and the teaching of programming or computer science are not included unless a CAI component is evident. CMI is differentiated from CAI in that the computer is used for tasks such as: diagnosing, assigning, routing the student through the curriculum, progress evaluation and related record keeping.

Methodology

Relevant literature dealing with effectiveness of CAI was located in several ways. The Educational Resources Information Center (ERIC) data base was searched using a variety of descriptors, and yielded many documents which would otherwise have been unavailable. The Education Index was used to identify relevant material published in the last three years. A search was also made of the Dissertation Abstracts International to locate recent doctoral dissertations which explored aspects of CAI. Other sources such as educational journals were scanned and a telephone survey of key individuals with CAI experience was conducted.

Even though more than 100 studies were examined, usable results of the review were less than anticipated. This was due to several reasons: (1) some potentially valuable research projects are currently underway, but do not yet have any data available; (2) the literature lags behind research by several months; (3) studies done by commercial suppliers of courseware are not included in this report; (4) the largest problem, however, is that many of the studies located were not usable because they did not apply accepted research techniques. Results and claims whose validity could not be verified by data within the study were not included. Many studies indicated positive results from CAI, but did not use other groups of students for comparison. These studies cannot answer questions about the relative efficacy of CAI as compared to other types of instruction. Student achievement data from such studies are not included in this report. Furthermore, the evidence of effectiveness has not been reported unless the likelihood of the results being due to chance is less than one in twenty.

Survey Results

Student Achievement in General

Several previous literature reviews (Jamison, Suppes, and Wells, 1974; Edwards, Norton, Taylor, Weiss, and Van Dusseldorp, 1975; and Thomas, 1979) examined studies on the effectiveness of CAI in student achievement.

Edwards et al. (1975) reported that all studies examined showed that normal instruction supplemented with CAI was more effective than normal instruction alone. When CAI was substituted, in whole or in part, for traditional instruction, studies were almost evenly divided as to whether students receiving CAI achieved more or about the same as non-CAI students. When different types of CAI were compared, mixed results were observed between increased achievement and no difference for CAI and non-CAI students. Edwards et al. (1975) also reported that CAI was equally effective when compared to individual tutoring, language laboratory, and various media, such as programmed instruction and filmstrips.

Thomas reviewed over thirty studies in a variety of disciplines which were related to the effect of CAI on achievement. Four studies showed approximately equal results for CAI and other modes of instruction; one study showed negative results (a beginning typewriting course). The other sources reported positive results with the use of CAI in basic mathematics, language arts, reading, career information, biology, algebra and physics. Drill, practice, simulation, tutorial, and problem solving types of CAI were all included.

Reading

Jamison et al. (1974) summarized the results of several studies dealing with applications of CAI to the teaching of reading, where it was shown to be an effective supplement to regular instruction. This was especially true with CAI drill and practice for students who start below grade level.

Two studies reported by Jamison et al. (1974) indicated that CAI tutorial programs in first grade beginning reading resulted in comparable scores for boys and girls. This is an important finding since boys, on the average, do not show an initial reading achievement level equivalent to that of girls. Litman (1977) analyzed the results for fourth through sixth grade students, and reported that after one year fourth and fifth grade males receiving CAI drill and practice scored significantly higher than non-CAI males. ("Significant" in this report means statistical significance at the .05 level, unless otherwise stated.) Anelli (1978), however, found that disadvantaged third and fourth grade girls gained more than boys.

Results of a three-year project for supplementary CAI in selected Title I schools in the Los Angeles Unified School District were reported by Ragosta, Jamison, Juhnke, Woodson, and Holland (1980). Students were pre-tested at the beginning of fourth grade and post-tested at the end of the sixth grade. The CAI students received three drill and practice applications from Computer Curriculum Corporation (CCC) in different combinations: mathematics, reading and language. A control group of students received no CAI. Students who used all three curricula scored significantly higher gains on the vocabulary subtest of the California Test of Basic Skills (CTBS) than did the control group.

At the end of the sixth grade, the same students were also given tests to measure specific material covered in the fourth, fifth, and sixth grade curricula. Those who worked with CAI mathematics, but not CAI reading or language arts, scored significantly lower on one section of the reading test, giving added credence to conclusions that CAI in reading and language arts did have positive effects. Ragosta et al. report that language arts scores, more than reading scores, were improved by using the reading and language arts curricula.

A parochial junior high school CAI project, conducted over a three-year period in an inner city section of New York City was reported by Wilkinson (1979). Students were predominantly black or Hispanic. Those receiving CAI scored significantly higher on the reading portion of the SRA Achievement Test than students in a traditional program.

Similar results were reported by Mravetz (1980) for rural, Caucasian junior high students who were reading at least one year below actual grade level. CAI students scored significantly higher on reading achievement than did comparable students having the same teacher.

Maser, Johnson and Davis (1977) determined that CAI drill and practice in basic skills was an extremely viable method for raising basic skills performance levels when used to supplement good teaching. Two school districts (Highline District, Seattle, Washington and Ft. Worth Independent School District, Texas) used CCC courseware for Title I reading and language arts, and reported gains in excess of one month for each month spent in the program. Participants in the three-year project were Title I students in grades two through nine. Lysiak, Wallace, and Evans (1976) reported that supplementary CAI generally increased vocabulary and reading scores in grades three through seven.

Mathematics

Maser et al. (1977) discovered that the objective of one month's gain for one month's participation for second through ninth grade students was also reached when using a Hewlett-Packard mathematics CAI program. Lysiak et al. (1976) reported mixed results for CCC mathematics materials in grades three through five, but indicated that middle school CAI students generally achieved more than control group students. Ragosta et al. (1980) reported that students who had received the CCC mathematics curriculum in grades four through six scored significantly higher on a curriculum-specific math test than did the control group. Wilkinson (1979) indicated that CAI students scored significantly higher on the SRA Achievement Test in mathematics.

Wells, Whelchel, and Jamison (1974) reported significant gains in mathematics (about one-third year higher than non-participants) for disadvantaged fifth and sixth graders in a Northern California black community. More frequent CAI experience lead to higher gains. Because participants were in their second year of CAI, the novelty of using computers could not be used to explain the results.

Fourth and fifth graders in San Diego who received CAI in mathematics scored higher than a control group on a district-made criterion-referenced test. Similar results were also obtained on a standardized norm-referenced mathematics test (Mills, 1979).

Romero (1980) conducted a controlled study of CAI with middle school mathematics students who scored below average on the Metropolitan Advanced Mathematics Test Series. The group which used the CAI mathematics laboratory gained significantly more in mathematics achievement than did students with only traditional instruction.

CAI drill and practice proved superior to workbooks in helping increase computational ability for remedial ninth, tenth, and eleventh grade students in a study conducted by Modisett (1980). Vincent (1977, 1979) found that EMR high school students using CAI for mathematics drill and practice achieved more than other EMR students.

Haberman (1977) studied the effects of CAI on emotionally and socially disturbed children who had been excluded from their regular classrooms. After two months, the CAI group had gained significantly more in grade equivalent than the control group.

A tutorial approach in algebra was reported by Pachter (1979). The CAI group was more successful in factoring second degree polynomials than the control group.

Other Subjects

Although the literature contains descriptions of many uses of CAI simulations in various social studies courses, few research results are reported. In one available study, Wilkinson (1979), found higher scores in social studies for junior high students who received supplementary CAI.

Dunkum (1979) found no difference in achievement when physics lectures were supplemented with computer simulations. However, it was discovered that teacher verbal dominance of the classroom decreased, student responsiveness and participation increased, and teacher receptiveness to student statements increased.

Several attempts have been made to present career information and guidance with CAI systems. Central Texas College (1973) combined tutorial CAI and videotape for eighth grade students in a Dallas middle school who were two or more years below grade level in reading on the CTBS. Emphasis was on Spanish-surnamed students, but learning increases were evenly distributed among blacks, Anglos, and Mexican-Americans with black females showing the largest gains.

In another study, high school sophomores who used a computer-assisted career guidance system scored significantly higher on all areas of vocational maturity as measured by the Career Development Inventory (Drake, 1978). Cassie (1976) also found that a CAI guidance information system increased career maturity attitude.

CAI has been used to teach the fundamentals of foreign languages. One study found no significant difference in achievement between a CAI group and a control group of high school sophomores studying beginning French. McEwen and Robinson (1976) point out the efficiency of CAI, however, since the CAI students spent 30 hours less in instruction. Another study involved beginning German at the college level. In a carefully controlled study at the Air Force Academy, Schaeffer (1979) observed that certain types of CAI drill and practice produced results in semantic meaning which were superior to the control group.

The preponderance of data indicates that CAI can be an effective means of supplementing regular classroom instruction. Most studies deal with reading, language arts, and mathematics skills, but the few reported studies in other subject fields also indicate the effectiveness of CAI instruction.

Attitude/Motivation

How will students react to using computers? Will teachers object to working with an electronic machine? The answers to these and similar questions are important considerations when deciding whether or not to use computers in instruction. The problem is that attitudes toward a class, subject, teacher, or school have been measured in a definitive manner even less frequently than has achievement.

Thomas (1979) found ten studies to review at the elementary and secondary levels. Those studies indicated that CAI students have either the same or a more positive attitude toward the instructional situation.

More recent studies of attitudes toward CAI follow the same pattern. Ragosta et al. (1980) report that fourth, fifth, and sixth grade students were enthusiastic toward CAI and complained if a CAI lesson was cancelled. Teachers were positive about the addition of CAI to the curriculum. In addition to academic achievement, the computer helped to provide a certain type of discipline; students were aware that good concentration helped to improve their scores. Students with short attention spans found the short problems and immediate feedback to be valuable.

How do students react when they discover that part of their instruction will include the use of computers? Beck (1979b) studied reactions of high school students with no previous computer experience who were told at the beginning of the course that they would be using a computer for portions of American History, Algebra I, and Computer Science. Computer Science students were significantly more positive toward CAI than students in American History, with Algebra I students in the middle. Nothing was mentioned about how these pre-attitudes correlated with achievement in the courses.

Maser et al. (1977) reported a high level of satisfaction from students, parents, participating teachers, and the faculty in general throughout grades two through nine.

Mravetz (1980) found no difference in self-concept between students who used CAI and those who did not, but results showed that CAI students shifted their levels of aspiration toward more realistic learning choices. Improved attitudes of individual responsibility and realistic decisions for learning were attributed to encouragement given by the CAI process.

The most thorough study of attitudes developing from the instructional use of computers was done by Deblassio (1978). Three-fourths of the students in advanced high school mathematics thought that the computer helped them to learn and nearly 90 percent thought using a computer was a favorable experience. Significant differences were found in personal characteristics between the students who were most favorable toward using a computer and those who were least favorable. The students most favorable were:

- favorable toward the overall instructional setting;
- high achievers in mathematics;
- above average in their liking of problems involving original thinking;
- above average in their amount of vigor.

Students who disliked using the computer were:

- unfavorable toward the overall instructional setting;
- average in their liking of problems involving original thinking
- average in their amount of vigor;
- likely to be more cautious and anxious than students who liked using the computer.

Casner (1977) explored the reactions of urban eighth graders to CAI in mathematics. No significant differences in attitude toward mathematics between CAI and traditional instruction were shown by females, but males in CAI classes were:

- less frightened by mathematics problems;
- less nervous at the prospect of having to do math problems;
- less likely to dread mathematics class;
- more likely to consider mathematics as fun.

Menis, Snyder, and Ben Kahan (1980) used CAI in tenth grade algebra with low achieving students who disliked mathematics. Not only did the CAI students improve their mathematics grades, but became less likely than the control group to report negative attitudes about mathematics and a variety of school-related issues at the end of the year.

Smith and Hess (1972) reported that CAI helped to promote the formation of realistic attitudes toward self-appraisal of junior high students' abilities in mathematics. Participants were predominantly Mexican-Americans who were initially two-to-three years below grade level in mathematics.

Compared to students in ordinary classes, Romero (1980) found positive shifts in student interest, conduct, and behavior patterns for low achievers in middle school mathematics who had CAI.

Vincent (1977, 1979) concluded that EMR high school students who had CAI in mathematics and reading had a more positive attitude toward those subjects than similar students without CAI.

Beck (1979a) reported student attitudes toward CAI in a sample of Nebraska high schools. Predominant usage was in computer science, mathematics, and various sciences. Females were significantly higher in attitude toward CAI. Attitude toward CAI was found to be related to certain personality traits of the student. Students who were more self-directed tended to be more favorable toward CAI.

Middle school students who were given career information by CAI and videotape had a positive attitude toward the experience (Central Texas College, 1973). Class attendance was higher for the CAI group, and students were enthusiastic toward the immediate feedback received from CAI.

Taylor (1979) surveyed students who received CAI in beginning German. A large majority thought of the computer as their private tutor. Eighty-six percent of the students agreed that the grammar learned in class was reinforced by the CAI explanations.

A few studies, such as Anelli (1978), report that enthusiasm was extremely high for CAI, but leveled off after either a long or short experience. However, most of these studies fail to indicate any hard data upon which these decisions were based. On the other hand, Wells et al. (1974) found that elementary students in their second year of CAI were enthusiastic about the experience. Smith and Hess (1972) found no difference in the pattern of results between students in their second successive year of CAI and those experiencing it for the first time. Many other studies and reports indicate that students had positive attitudes about CAI, but do not indicate how this conclusion was determined.

Time Reduction

Claims have been made that the use of CAI will reduce the amount of time needed to learn a concept. Edwards et al. (1975) summarized nine studies which indicated that CAI students learned as much or more than students in traditional instruction, but that the time taken for a student to achieve equal results was reduced. Eight of the nine studies were at the elementary level. Thomas' survey of ten studies concluded that at both elementary and secondary levels CAI reduces the amount of time required for a student to complete a unit.

Current literature contains many references to the time saving benefit of CAI, but only one report of research at the elementary and secondary levels was located which documented the time savings. McEwen and Robinson (1976) reported that beginning French students who received CAI spent about 30 fewer hours in classroom instruction, but achieved at the same level.

Retention of Material

Impressive results which attest to the effectiveness of CAI have been described. These comparisons have generally been based on results attained at the end of a certain period of instruction. What about the student's retention of material over a longer period of time?

Edwards et al. (1975) found that two of three reported studies indicated that CAI students retained material less well than the non-CAI students. Both of the studies reported by Thomas (1979) indicated retention of learned materials which was about the same for CAI and non-CAI students. Litman's study (1977) of remedial readers showed that males receiving CAI maintained their advantage over non-CAI males when retested after two years.

As in other educational endeavors, the amount of data relating effects of CAI and retention of material is sparse. The data which do exist are inconclusive concerning whether CAI helps students retain more of what is learned than do students receiving traditional instruction.

Teacher-Student Interaction

Fears have been expressed that the use of computers in the classroom would decrease the amount of teacher-student interaction. Three studies measured the interaction of teachers and students while CAI was being used to supplement regular instruction. Dunkum (1979) discovered that physics teachers lectured less, provided less negative feedback to students, and were more accepting of student responses than the same teacher during a similar class without CAI. The variety of teacher-student interaction increased for CAI classes. Haberman (1977) found that EMR high school students using CAI did not receive as much teacher attention as students receiving only traditional approaches. Students increased their self-reliance. Romero (1980) reported that CAI helped to lessen the teacher's duties in middle school mathematics which led to more productive student-teacher interaction.

Summary

The data indicate that CAI which supplements traditional instruction is effective in increasing learning by elementary and secondary students. In fact, the weight of evidence is overwhelmingly in favor of CAI. Not only has CAI been shown to contribute to higher student achievement, but there is evidence of positive student acceptance of the use of computers in the classroom. Although research is sparse, it also appears that CAI can decrease the time required to learn subject matter.

Unanswered questions exist relative to long-term retention of learned material and teacher-student interaction. These areas have been researched more frequently at the collegiate level with generally positive results, but little acceptable research has been done at the elementary and secondary levels.

Taken as a whole, the literature indicates that CAI is effective in helping students learn when used as a supplement to regular instruction.

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Computer Education Cost Considerations

A cost analysis of the alternatives for computer education is a task a district can and should carry out in developing long-range plans and budgets. This report presents a variety of approaches to cost analysis and recommends one approach. A cost analysis of hardware and courseware requirements for one mode of instruction is presented as an example.

Approaches to Cost Analysis

One of the important factors influencing a district's choice of alternative computer instruction configurations is economics. Three assumptions are postulated:

1

1. Any major expenditure is out of the question in the near future.
2. Expenditure cuts are likely for any activities that don't appear to contribute to the essential needs of a district's students.
3. Methods for controlling expenditures in the long term are desirable.

It is therefore essential that any discussion of potential options in the area of computer instruction include an analysis of the costs of each option. This report discusses three alternative methodologies for completing a cost analysis, and describes in detail a set of procedures to be used in conducting a cost feasibility analysis.

A number of approaches are available for conducting a cost analysis. These include cost-benefit, cost effectiveness, cost utility and cost feasibility. While the first three approaches are potentially more powerful tools than the cost feasibility analysis, each of the three is more difficult to conduct, and subject to wider variations due to subjective decisions which must be made. consequently each will be reviewed briefly, and a more detailed description of a "resource approach" to cost feasibility analysis will be described in more detail.

Cost-Benefit Analysis attempts to compare the costs of a given project with the expected benefits of that project. In general, both costs and benefits are expressed in monetary terms, generally discounted to a present value. Each alternative project can then be ranked based on the benefits it will provide. To conduct a cost-benefit analysis it is necessary to determine the lifetime costs and benefits associated with a particular project. In the field of education, it is relatively easy to calculate the costs of a project since they are largely costs associated with equipment, personnel, supplies and materials. On the other hand, benefits are more difficult to measure in monetary terms. For example, it is difficult if not impossible to place a monetary value on an individual from a specific education program, either through higher lifetime earnings, or through greater appreciation of life in general. It is also difficult to measure the monetary benefits to society from a child's participation in a particular educational program.

Because of the difficulties in assigning monetary figures to the benefits of an educational program, cost-benefit analysis is rather limited in its applications to educational situations.

Cost Effectiveness Analysis tries to compare the relative effectiveness of alternative programs or projects. An example in the field of education would be two alternative programs which were shown to lead to achievement increases above that of a control group. For example, Program A has costs of $100 per pupil and leads to an average achievement gain of one grade level, and Program B has costs of $25 per students with average achievement increases of half a grade level. A comparison of the two alternatives would show that Program A leads to one grade level increase in achievement for each $100 spent while Program B leads to one grade level increase with an expenditure of $50. As a result, a cost effectiveness study would tell us that Program B is more cost effective because an expenditure of $100 will lead to an achievement gain of two grade units as opposed to a one grade level achievement gain for the same $100 spent in Program A.

It should be pointed out that this is an aggregate measure of all students in the school. In Program A, each student who participated in the program gained one grade unit, while in Program B, each student who participated gained half a grade unit. However, when all of the achievement gains measured as a result of equal expenditures in each program are totaled, Program B has better results.

What a cost effectiveness study does not tell us is which result is preferable. Clearly, Program B maximizes the return on dollars spent, but in many instances in educational practice, this may not be the only sound basis for decision making.

Cost Utility Analysis considers another problem inherent in cost analyses in the field of education. That is the fact that in many instances there is no available data to determine the expected success level of a given program. Both Cost-Benefit and Cost Effectiveness Analysis require specific quantitative data to construct their evaluations. Cost Utility Analysis allows the use of more subjective data in terms of the expected outcome of a particular program. For example, the probability of raising achievement by one grade level equivalent is used in calculating the expected utility. In addition, assumptions about the relative utility of various gains in achievement in different academic areas can also be factored into the decision making process to determine which project is better for the needs of the education agency.

Unfortunately, it is exactly this subjective nature of the data used that limits the usability of Cost Utility Analysis. Consequently, the results of such an analysis cannot be reproduced on the basis of standard methodology, since most of the assessments are highly subjective and will vary from evaluator to evaluator.

The major problem with each of these three approaches is that they require data which in many cases is not readily available at the present time. As the summary of the research indicates, there is significant evidence that the use of computers in instruction does add to improved educational outcomes. However, the research also points out the difficulty of measuring that increased attainment, making cost-benefit and cost effectiveness analysis difficult at the present time.

Finally, the immediate problem facing a district is what types of computer instruction it wants to offer, and how to finance those alternatives. For this purpose a cost feasibility analysis is the most appropriate. Such an analysis will provide a district with enough information about the expected costs of each potential portion to allow it to make a decision regarding the kinds of services it wishes to provide for students within existing budget constraints.

The Resource Approach to Cost Feasibility Analysis

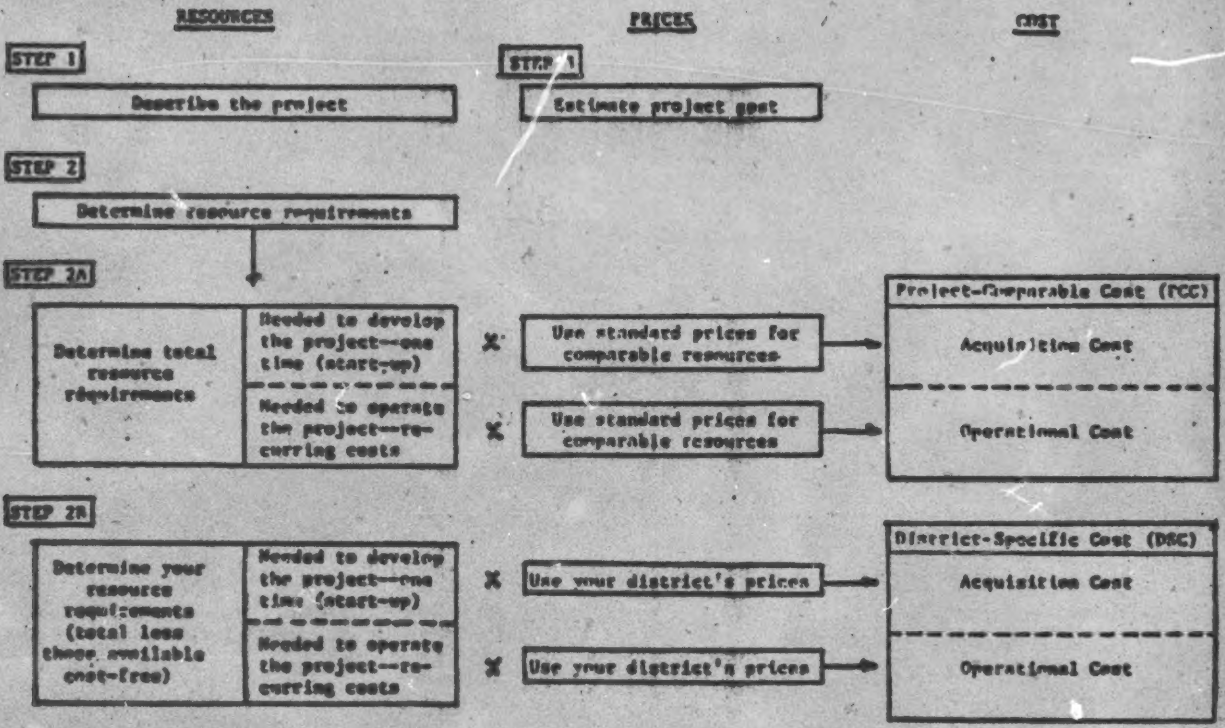
One of the most useful and simple approaches to cost feasibility analysis can be found in the HEW publication The Resource Approach to the Analysis of Educational Project Cost (U.S. Government Printing Office, Washington, D.C., 1978, SN 017-080-01914-1).

The Resource Approach details a series of steps that a school district should take to develop cost estimates for the development and implementation of new educational programs. There are two levels of analysis. The first, called Project Comparable Costs (PCC) establishes a framework whereby a variety of alternative projects or programs are compared using a set of standard prices for comparable resources. The second level of analysis calls for the development of a District Specific Cost (DSC) for the alternatives that appear to be the most practical based on the PCC analysis conducted earlier.

Table 1 summarizes the whole process from start to finish. As the table shows, the first step is to describe the project in enough detail to determine what the final product will look like. At the same time an estimate of total costs, or what the district is able to spend on the project, should be made.

The second step in the process is to determine all of the resource requirements of the proposed project. These should be divided into two categories, acquisition or one-time costs, and operational costs. It is important to differentiate between these categories since two apparently similarly priced projects may have significantly different long-term costs if one of the projects has relatively high acquisition costs and relatively low operations costs compared to the other project.

Table 1: THE PROCESS OF ESTIMATING PROJECT COST


RESOURCES
PRICES
COST
STEP 1
Describe the project
STEP 3
Estimate project cost
STEP 2
Determine resource requirements
STEP 2A
Determine total resource requirements
Needed to develop the project--one time (start-up)
Needed to operate the project--recurring costs
X
Use standard prices for comparable resources
X
Use standard prices for comparable resources
Project-Comparable Cost (PCC)
Acquisition Cost
Operational Cost
STEP 2B
Determine your resource requirements (total less those available cost-free)
Needed to develop the project--one time (start-up)
Needed to operate the project--recurring costs
X
Use your district's prices
X
Use your district's prices
District-Specific Cost (DSC)
Acquisition Cost
Operational Cost

Source: HEW The Resource Approach to the Analysis Of Educational Project Cost

The third step is to cost out each of the resources necessary for each project alternative. Among the kinds of information needed to describe the project adequately are the following:

1. Students
   a. Characteristics
   b. Number To Be Served
2. Instructional Data
   a. Class Size
   b. Class Time
3. Facilities
   a. Space
   b. Students/Classroom/Day
   c. Utilization
   d. Furnishing
4. Equipment
   a. Project Related
   b. Student Related
5. Pre-Service Training
6. In-Service Training
7. Support From Other Activities

Once the general description of the resources necessary has been developed, the Project Comparable Cost for each alternative can be developed. This is done through estimating a standard cost for each resource unit. For example, a standard amount is established for each teacher's salary and each aide's salary. Similar standard amounts can be established for each of the other resources identified in the process above. Once determined, a Project Comparable Cost for each option under consideration can be determined.

This procedure will allow a district to rank each project by cost, allowing it to make an informed decision regarding which of the alternatives can be considered for implementation and which cannot, due to the financial limitations of the district.

It must be pointed out that the PCC will not provide a final estimate of what the project will cost, but will give a district a way to compare the costs of alternative proposals under equal assumptions. This is particularly true when the projects being reviewed have been established on differing scales. If one is in use in a school district with 400 students and the other in a district with 40,000 students, then adjustments must be made for the differences in scale. By determining the resources necessary for implementing each project, and estimating the costs of each with standard price units, a district can determine the relative costs of implementation.

The fourth step in the process is to calculate the District Specific Cost for those projects which appear to be the most feasible based on the PCC analysis. To do this requires the determination of the specific resource requirements for implementation of each project in the District itself. Therefore resource needs must be determined and costed out using actual district cost factors.

The following specific items must be considered in the analysis of the costs of installing a computer instruction program in a district:

A. Acquisition Costs

  1. Hardware
  2. Software
  3. Curriculum Development and/or Selection
  4. Teacher Training
  5. Evaluation Design
  6. Facilities
     a. Purchase of Space
     b. Remodeling of Space
     c. Installation of Equipment

B. Operational Costs

1. Maintenance and Replacement of Hardware
2. Updating and Replacement of Software
3. Updating or Revision of Curriculum
4. Periodic Inservice Sessions
5. Evaluation Services
6. Utility Charges
   a. Phones
   b. Power
   c. Computer Time Charges
7. Transportation Costs
8. Salaries
   a. Teachers
   b. Aides
   c. Specialists
   d. Other
9. Management Support Services
10. Material and Supplies
11. Contracted Services
12. Media Services

Once this cost analysis has been completed for the one or two options that appeared most feasible through the Project Comparable Cost methodology, a final decision may be made as to which, if any, of the projects should be implemented by a district. A district at that point should have a good description of what that implementation will entail, as well as a good estimate of the costs involved.

Cost Analysis: An Example

Providing computer-based drill and practice in math, reading and language arts is one of the alternatives available to a District, and has a high priority for schools where deficiencies exist in these areas.

As an example, this alternative will be analyzed to determine costs for hardware and courseware.

Cost per student-hour (of keyboard use) can be determined and compared for several hardware options. A comparison will be made between three possible hardware configurations:

System A	Stand-alone microcomputers (e.g., Apple II)
System B	A microcomputer "cluster" (e.g., TRS-80 Network I with 16 keyboards;
System C	A minicomputer-based timesharing system (e.g., Computer Curriculum Corporation)

SYSTEM A: STAND-ALONE MICROCOMPUTERS

o Optimum configuration--operation cost per student-hour obtainable with a minimum of one student station	
o Purchase of equipment (one Apple II Plus with 48K memory, two disk drives)	3000.00
o Maintenance contract (1 year estimate)	600.00
TOTAL	3600.00
o Each additional year of operation (Maintenance estimate)	600.00
o Cost for 5 years of operation	6000.00
o Cost per year (5 year utilization)	1200.00
o Cost per student station/year	1200.00
o Cost per student hour (1000 hours/year)	1.20

SYSTEM B: MICROCOMPUTER CLUSTER

o	Optimum configuration--16 student stations	
o	Purchase of equipment (16 16K Level II TRS-80s, 1 Radio Shack Network I Controller, 1 TRS-80 disk system with 16K expansion interface and 2 disk drives)	16,379.00
o	Maintenance Contract (1 year)	2,457.00
	TOTAL	18,836.00

o	Each additional year of operation (maintenance estimate)	2,457.00
o	Cost for 5 years of operations	28,664.00
o	Cost per year (5 year utilization)	5,733.00
o	Cost per student station/year	358.00
o	Cost per student-hour	.36

SYSTEM C: MINICOMPUTER-BASED TIMESHARING SYSTEM

o	Optimum configuration--96 student stations	
o	Purchase of equipment (CCC timesharing system and 96 student stations)	332,600.00
o	One year maintenance contract and courseware charge	71,352.00
o	Installation	15,200.00
	TOTAL	419,152.00

o	Each additional year of operation (maintenance and courseware charge)	71,352.00
o	Cost for 5 years of operation	704,560.00
o	Cost per year (5 year utilization)	140,912.00
o	Cost per student hour (does not include telephone charges)	1.47

These costs are not directly comparable, since System C includes courseware (math, reading and language arts) costs, while the others do not. Grades one through six Math courseware for System A, for example, sells for $1,000. Kindergarten through eight Math courseware for System B is available for $199. Reading and language arts courseware are not yet available for either system. Availability, quality and effectiveness of courseware are of paramount concern.

Requesting bids for a system to provide basic skills drill and practice could result in lower costs than those quoted here.

If we include the cost of math courseware in Systems A and B, the comparable costs are:

Cost of Delivering Math Drill and Practice (Hardware/courseware only)	5-yr. cost hardware alone	5-yr. cost incl. math courseware	1-yr. cost for math	cost per station/yr.	cost per student hour	cost - 100 students @ 15/min.day each
System A: Microcomputers (e.g. Apple II)	$6,000	$7,000	$1,400	$1,400	$1.40 math only	$35/day
System B: Cluster (e.g. TRS-80)	$28,664	$28,863	$5,773	$361	$0.36 math only	$9/day
System C: Time-shared (e.g. CCC)	NA	NA	NA	NA	$1.47 all basic skills	$36.75/day

If we assume that reading and language arts courseware will soon be available for Systems A and B at costs comparable to the math courseware, then costs would be:

Cost of Delivering Math, Reading and Lang. Arts Drill & Practice (Hardware/courseware only)	5-yr. cost hardware alone	5-yr. cost incl. all courseware	1-yr. cost all basic skills	cost per station/yr.	cost per student hour	cost - 100 students @ 15 min./day each for each of 3 basic skills
System A: Microcomputers (e.g. Apple II)	$6,000	$9,000	$1,800	$1,800	$1.80	$135/day
System B: Cluster (e.g. TRS-80)	$28,664	$29,264	$5,853	$366	$0.37	$27.75/day
System C: Time-shared (e.g. CCC)	NA	$704,560	$140,912	$1,468	$1.47	$110.25/day

The assumption that each student requires 15 minutes per day of computer-based drill and practice for each basic skill area would not hold for other modes of computer education. Simulation, for example, is a mode of instruction which can be used effectively with groups of students up to a full class. An hour of interaction involving a class of 30 students with a simulation, then, would be the equivalent of 30 student-hours provided by a single keyboard.

In computer science classes, on the other hand, it could be necessary to provide at least one student station for every two students, because of the continuing need for hands-on access to the computer.

The hardware/courseware costs for computer education will vary, then, by mode of instruction. A single keyboard can serve up to 25 students a day for drill and practice, 12 students a day for computer science classes (2 per class period) or as many as 180 students a day in simulation mode with six classes of 30 students each.

Teacher Competencies for Instructional Computer Use

A literature review of teacher competencies needed for classroom microcomputer implementation revealed that there was no consensus among "experts" regarding minimum competencies required by teachers to implement computer technology in the classroom. Some individuals felt a 3-credit orientation course was a basic requirement for every teacher, while others believed teachers should have several courses in computer science. The following review is presented to provide background information for a district interested in developing a staff development program/teacher training program.

A Literature Review on Teacher Competencies

Most of the published materials are in the form of journal articles rather than books. Books tend, at this point, to provide good information on computers and their uses but little information on microcomputers. Several articles deal with computer literacy as a phenomenon capable of having more impact on our society than any other educational development experienced to date. The microcomputer, because of its relative low cost and availability, is becoming highly feasible for classroom utilization. "Computer power will become available to students and teachers alike. Computer literacy will be as common as reading ability is today and those who are not computer literate will be at as much of a disadvantage in society as someone who cannot read is today," (Mazur, August 1980).

The literature tends to be a bit repetitive in that all of the authors see a need for teachers to become computer literate. They differ, however, in the degree of instruction needed for teachers to implement microcomputers successfully into the instructional process. Milner expresses the concern that educational opportunities are being missed because most teachers do not know how to use computers nor can they teach their students about computer impact on society (Milner, April 1980). This same concern is voiced by Bass, who feels that teachers do not truly realize the potential of the microcomputer as a teaching resource or teacher's aide (Bass, Brown and Nold, September 1975). Miller makes the statement that computer literacy is becoming a new educational catch word. She feels that the educational system is not moving rapidly enough to teach skills necessary to keep pace with the technology (Miller, April 1980). This concern is expressed by other authors who agree computer literacy will be left to the dubious methods of industry if educators do not assume some responsibility for developing courseware and preservice or inservice education for teachers.

Two surveys were reviewed which addressed educators' attitudes toward computers in the classroom. The Lichtman survey (which was a small, restricted sample consisting of summer teachers at the College of Education, University of South Carolina) addresses general attitudes of educators toward the computer (Lichtman, January 1979). The Stevens survey in Nebraska deals with classroom perceptions of the computer. Her findings indicate that Nebraska educators are indeed favorable to development of computer literacy but that they as individuals do not feel qualified to teach computer literacy (Stevens, Spring 1980). Consequently there is apparently much support for instilling computer literacy in students but little consensus regarding what teachers must know in order to accomplish the task.

Henderson approaches training from the certification point of view--all teachers and administrators should complete a minimum of two courses in computer science in order to fulfill general certification requirements. Included in the courses would be a general orientation to computers and their systems as well as computer impact on schools and society. He then breaks educators into four groups: elementary teachers, secondary teachers, administrators, and computer science specialists with appropriate coursework suggestions listed for each level (Henderson, August 1978). Apparently these recommendations are his own opinion because no bibliography was provided.

Stuart Milner believes that many educators know very little about potential applications of computer technology in the classroom. Low priority status, lack of available coursework, and lack of incentive for implementation are some of the reasons illustrating the need for increased administrative support and recognition. Milner also includes a brief discussion of attitudinal surveys conducted with teachers and administrators which he felt was inconclusive. There are six suggested coursework areas which Milner feels are essential for teachers:

1. An introduction to instructional design
2. Design of computer based materials
3. Programming--2 courses
4. Hardware and software organization
5. Use of computers in society
6. Use of computers in education

Milner feels his outline can be used to identify needs and establish course requirements for teacher education. However, an attempt to include all of these courses in a tight preservice or inservice education curriculum may actually deter a district from microcomputer implementation.

The NECC Proceedings for 1979 contained several articles dealing with teacher competencies. Taylor and others define these competencies in three ways: those needed by all teachers, those needed by the teacher of computing as a subject, and those needed by teachers who wish to use computing to support their subject matter. Competencies included in the first category are as follows:

- be able to write programs and subprograms that work correctly and are easily readable by others, and be familiar with how such programs and subprograms fit together into systems;
- know what general types of problems are amenable to computer solution and the various tools necessary for solving such problems, particularly in using computers in education;
- know what general types of problems are not currently amenable to computer solution and why not, particularly in using computers in education;
- be able to duscuss at the level of an intelligent layperson the history of computing, particularly as it relates to education;
- be able to identify and generally rate several alternate sources of best current information on computing as it relates to education;
- be able to discuss moral or human-impact issues of computing as they relate to: (a) societal use of computers generally, and (b) educational use particularly.

Further elaboration on course content is then provided for all three categories.

Also included in the NECC Proceedings is an article by J. Richard Dennis. Although he does not deal specifically with competencies he does divide computer-using teachers into three stages of personal growth, each deserving of unique training considerations. These states are:

awareness, implementing, and growth maintenance. Dennis also distinguishes between characteristic preservice and inservice training and proposes models for each.

The last item which deals with teacher competencies was prepared under Dennis' direction and intended as a resource guide for preservice and inservice teacher education. In this report are included the following 25 skills necessary for computer-using teachers.

1. Familiarity with computerized teaching materials (i.e., instructional programs) in a variety of fields.
2. Ability to integrate computerized teaching materials into a course.
3. General knowledge of the function of CMI (computer-managed instruction) systems.
4. Understanding of effective design of drill and practice materials.
5. Ability to apply computerized drill and practice in a variety of teaching situations.
6. Familiarity with computer-based simulations and models.
7. Experience in preliminary design and construction of a simulation.
8. Knowledge of the uses of simulations as teaching tools.
9. Ability to evaluate the effectiveness of a course that uses computerized teaching materials.
10. Ability to determine the computer needs of a school.
11. Ability to draft specifications (request for proposals) which set down the needs and desires of the school and invite proposals or bids from potential suppliers.
12. Ability to be highly critical of suppliers' proposals and their machines.
13. Ability to assemble data about proposed equipment to facilitate decision-making (costs, performance data, hardware characteristics, software support, etc).

14. Familiarity with instructional games.

15. Knowledge of how to use instructional games appropriately and effectively in teaching.

16. Physical familiarity with computer equipment, i.e., everyday operation and use of a range of different machines.

17. Knowledge of trouble shooting procedures and means of access to professional help, i.e., knowing how to determine if a piece of equipment is ailing, if it is, knowing whom to call to fix it.

18. Knowledge of sources for computer materials.

19. Knowledge of how to improve less than adequate instructional computer programs.

20. Ability to evaluate the effectiveness of instructional computer programs.

21. Ability to instruct others in the social role and impact of computers in society.

22. Knowledge of alternative uses of computers in schools, i.e., as class record-keepers, term paper editors, etc.

23. Awareness of the value of involving students in the development of computerized instructional materials.

24. Knowledge of processes of involving students in instructional materials development.

25. Knowledge of computer programming.

Summary

It is important to emphasize that at this particular time there is no consensus regarding competencies needed by teachers for successful classroom computer implementation. Virtually no distinction has been made for the microcomputer or its accompanying software. The literature does suggest several key areas in which teachers should receive training, although how much training is required (i.e., programming) is a matter of some disagreement. Since each school is unique, perhaps there can never be any one program that is right for everyone.

Minimum competencies for all (or most) teachers must be defined by the district, with additional competencies specified for teachers of computer science or programming.

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The Status of Instructional Computing

The Commercial Sector

This report will identify and describe the various categories of commercial providers of instructional computing products and services as possible resources for a district interested in purchasing microcomputers. It will also describe the changing roles various types of companies are taking in this new and growing market.

The Traditional Roles of Manufacturers and Publishers

Traditionally in the education market, hardware companies, designers and manufacturers of computers also develop software, including application programs and languages. The small-to-medium size timesharing computers have been the mainstay of instructional computing hardware in the 1970s.

Software development and distribution proceeded mainly in two ways. First, computer manufacturers organized and supported user groups. Users of a given company's hardware would contribute programs to the user group. The collection would then become the "contributed library," available to all users when they acquired a computer. In some cases, such programs were enhanced by the manufacturer and became products of the company, with full support. In other cases, they were left to be used on an as-is basis at the user's risk.

The second method of development was the investment by a hardware manufacturer in a development staff for educational applications, or in contracts with people to develop applications. In most cases, the investment was short-term, lasting a few years.

Companies which produced only software for instructional use did not exist until the late 70's. Publishers were not involved in producing software, but did publish programming texts.

Current Changes in Roles

The advent of inexpensive, portable microcomputers with capabilities for enhancing the utility of computer applications has begun to change the roles described above.

In the hardware area, many new companies are being formed. The implications are that many new alternatives are available to schools in the selection of hardware, and that many of the new and attractive alternatives are produced by companies who do not have a track record in production, delivery and support.

A second trend is that hardware companies are not investing in application software development as much, but are emphasizing the development of software tools for application development, such as operating systems which are easier to use and author languages to support and simplify the process of instructional development.

Thirdly, while manufacturers of medium and large scale computers still maintain field engineering staffs who will perform on-site maintenance, the microcomputer manufacturers may perform maintenance on a carry-in or mail-in basis. That is, the user brings the machine to a repair station, or mails it in.

Finally, sales representatives are usually employed by the manufacturer in the case of medium and large scale systems, whereas in the microcomputer field, independent computer stores, department stores and mail order houses market many of the brands. Several microcomputer companies have, however, set up special national offices to respond to large scale acquisitions by RFP from school districts or consortia.

In the area of software and courseware, there are two major recent trends of importance. First, the major textbook publishing companies are producing or planning to produce courseware. One implication of this trend is that courseware development is in the hands of those who have experience in the preparation of instructional materials rather than computer people. Also, the computer-related materials will be coordinated with and supportive of texts and other products for classroom use, which means less teacher effort for implementation.

Another implication is that publisher's representatives are in regular touch with schools, and have a more natural avenue of contact than the computer industry. As a result of that and other considerations, publishers and microcomputer manufacturers are in several cases making agreements which result in courseware being developed by a publisher for a specific computer, and the computer being sold to schools by the textbook salesperson. A possible disadvantage to the schools is that non-hardware oriented people will be trying to sell hardware. An advantage to schools is that the focus will be on the application rather than the hardware.

The second major trend in software and courseware development is the proliferation of new small companies which are specifically constituted to develop and market instructional software and courseware. They develop materials sometimes under contract to a publisher and sometimes to be marketed themselves. This trend offers the same advantages and disadvantages as the advent of new microcomputer manufacturers previously mentioned. That is, the variety offers more alternatives, but the question of track record of quality and support is unanswered.

A major problem which has existed for many years in the computer industry, and which still exists in the microcomputer era, is the lack of hardware and software compatibility between hardware brands, and even between different lines of hardware from the same manufacturer. The problem is exhibited in several ways.

A given application may run only on the computer for which it was written. Two different brands of computer have differing versions of the BASIC language, so programs may take advantage of special characteristics of one brand that do not exist on the other, or the material may be stored in a pattern on the magnetic disk for one machine which is unreadable by the other. Conversion of a program from one machine to another is possible, but is time consuming, expensive, and may be, in some cases, prohibited by copyright or agreement with the publisher. It is furthermore unreasonable to expect the situation to change very much very soon, since product differences are part of the marketing strategy in a competitive system. Of course, standardizing all acquisitions on one brand is a way around the problem. However, in doing so a district will forego the use of desirable courseware written for other brands. In some cases, material is being written for more than one machine by the developer, but the number of such cases is limited. The SRA publishing company is one example, producing their material for two different brands.

Activities in Other Large City Districts and Metropolitan Consortia

In addition to commercial sources, another potentially beneficial resource to a district is other large school districts and consortia around the country. Because of their experiences they are potential sources of information, courseware, and development assistance.

Philadelphia School District

The Instructional Systems Division, Philadelphia School District has been involved in providing computer time and inservice instruction to the teachers in the District, and developing courseware. Development is in the areas of career guidance, basic skills and instructional management. Services are provided through Hewlett-Packard 2000 and 3000 timesharing computers. They have taken a very general approach to instructional applications, supporting a library of programs in all the various modes of computer use. Current activities involve developing microcomputer programs for elementary school computer literacy instruction.

Minneapolis Public Schools

For about 10 years the Minneapolis Public Schools have operated a 32-line timesharing system with a general library of applications. System uses cross all grade levels and application areas. The schools also access the statewide timesharing system operated by the Minnesota Educational Computing Consortium. Minneapolis, with grant funds from the State of Minnesota, has developed software for a mathematics worksheet generation system for several grade levels which provides an efficient use of computer time.

St. Paul, Minnesota School District

The St. Paul, Minnesota, school system has been a partner with Minneapolis in their development activities. Coordination of instructional computing in both Districts is lodged at the Mathematics Supervisor's office. Both Districts participate in the computer activities of the Twin Cities Institute for Talented Youth. The St. Paul

District has also experimented with the PLATO system on a limited basis. They have made extensive use of mark-sense card readers as tools for making programing instruction efficient.

Chicago School District

Chicago uses drill and practice in basic skills extensively. Approximately 1,400 timesharing terminals for student use are located in 70 schools. The current mainframe is a UNIVAC 1110, but will likely be replaced soon with a UNIVAC 1160. The average response time to a student's input is two seconds; system specifications call for a maximum of three seconds. Quick turnaround time is thought to be essential for students with short attention spans; they will not remain motivated if there is a long wait. Students use CRTs, but a printer is available in each school. Teachers get a daily printout of student progress.

Los Angeles School District

Los Angeles has computers in 12 schools, both elementary and secondary, with approximately 30 terminals per school. This arrangement avoids phone line charges and gives more capability than microcomputers. Computers include seven Hewlett-Packard 2000 series timesharing computers and 5 machines furnished by Computer Curriculum Corporation (CCC). Some schools have microcomputers for administrative purposes, but the impression is that they are not satisfactory. A test item bank is available, as is a test scoring service with overnight turnaround.

Dallas School District

The Dallas, Texas, School District has long been involved in the development of instructional systems using technology. They have developed elementary mathematics basic skills material for microcomputer presentation. They have also developed a bilingual reading system, recently converted from a larger computer to a microcomputer, employing a voice synthesizer. Both sets of courseware are available for purchase from the District.

Kern County Schools

The Kern County Schools (Bakersfield, California) have three high schools using CCC computers and courseware for Title I students. This District has discovered that teacher training in use of the courseware is vital for optimum results.

Highline District

The Highline District in suburban Seattle uses CCC computers and courseware along with remedial instruction for Title I students in grades 7-12. In grades 2-6, CCC materials are used for drill and practice for students below the 35th percentile These students receive no other remedial instruction.

Medford and Corvallis Districts

Both Medford and Corvallis School Districts in Oregon are involved in the use of microcomputers instructionally. Corvallis has placed machines in every secondary school and uses them for programming instruction and computer literacy activities, Medford's use is focused on Title I students. They have developed basic skills materials for timesharing use, and are now involved in conversion of that material and others to microcomputers.

Consortia

Many consortia, county units and ESD-type organizations now provide instructional computing support. Prominent among these are TIES (Minnesota), Jefferson County (Colorado), Wayne, Oakland and MaComb ISDs (Michigan), Region 10 (Dallas, Texas), and Region 4 (Houston, Texas). These services are somewhat like the services provided by Multnomah ESD, although Minnesota, Michigan and Texas are very active in software and courseware development and in the support of microcomputer acquisition and use.

Summary

There are many resources, both commercial and non-commercial, from which a district can draw assistance. The expectation for increased availability of courseware in tune with District needs is good. Much of that courseware will be developed specifically for microcomputers, and will be correlated with standard text series. A district will be able to benefit from contacts with many other large urban districts whose experience in specific applications of computers is more extensive.

Recommendations for District Personnel Interested in Implementing Microcomputers in Education

Curriculum

1. A district should develop goals, objectives, and content outlines for the subject areas of computer literacy and computer programming.

   With regard to computer literacy, activities should be specified at elementary, middle and high school levels. High school activities can be planned as an elective course or as units in mathematics, science and social science classes, with specific plans to phase them out or change their nature as students begin to come from elementary and middle school experiences already possessing the desired concepts. The objectives should be viewed ultimately as requisites, with the elective nature of such instruction phased out as soon as possible, if implemented at all. This recommendation can best be implemented in stages by clusters of elementary and middle schools with each high school so the progression of student experiences implied above can be achieved.

   With regard to computer programming, two one-year courses should be developed. The first course should be available at both middle schools and high schools, and the second course at high schools. Any programming experiences at the elementary levels should be considered as part of the computer literacy experience. Objectives in these courses should be correlated with the mathematics curriculum. If, for example, it is desired to assume that students in certain math courses will use computers to complete assignments, then either the first semester of the first programming course should be a prerequisite to the math, or some portion of the programming objectives should be embedded in the math course.

2. A district should consider supporting basic skills instruction in mathematics, reading, and language arts at elementary, middle and high school levels with computer-based drill and practice and tutorial materials.

   Because of the need for thorough teacher training for proper use of such systems, a phased approach, implementing one new subject area at a time is advisable. A district should also determine in advance in which schools the students are most deficient in those skill areas.

3. A district should explore the use of a computer to support the diagnostic and prescriptive activities of instruction for special education students.

4. A district should develop a sequence of implementation for computer support of subjects and levels not addressed in the previous recommendations, and should schedule a periodic review of resources and directions of instructional computing.

   Such a review is necessary because of the rapid changes now being experienced in hardware and courseware development which can easily cause changes at the detail level. Overall curricular priorities can be expected to be more stable and should always guide technology implementation decisions.

Hardware

5. A district should develop specifications for, and acquire, one type of microcomputer for general purpose computing at all levels. The number of units and schedule of acquisition should be commensurate with the rate of implementation of the curricular Recommendations, but all acquisitions under one specification should occur within a two-year maximum time span.

   A district should consider establishing in at least one school a microcomputer laboratory of 15 to 30 units of the kind selected as a result of this specification, to support District-wide inservice instruction as well as programming classes in selected school(s).

Software and Courseware

6. A district should conduct a comparative analysis of the micro- and minicomputer-based basic skills courseware available.

7. A district should acquire microcomputer-based courseware for use in a wide range of subjects and levels on the microcomputer type selected under Recommendation 5.

8. A district should seek opportunities with major publishers or other developers of computer-based materials for serving as a field test site for courseware, for purposes of evaluation for potential use and keeping abreast of developments.

Personnel

9. A district should appoint a Computer Education Coordinator in every building where a terminal or computer is placed to plan, coordinate and supervise the use of the equipment in correspondence with the curricular plans in Recommendations 1-4. Time should be provided in the schedule of such persons for inservice and carrying out the assignment.

The amount of released time should depend on school size and amount of hardware. Familiarization of other staff members with relevant uses of the computer should be a prime concern of this person.

10. A district should appoint a District Computer Education Coordinator with full-time responsibility for planning and implementing the instructional computing activities recommended in this report.

11. A district should assign staff time to develop the objectives, specifications and other activities implied by the curricular, hardware and courseware recommendations.

12. A district should plan and implement an inservice program to support the curricular recommendations, with specific programs initially for curriculum consultants, building administrators, computer education coordinators, teachers of computer literacy and computer programming, teachers using basic skills systems and teachers needing an overview of the uses of computers in instruction.

ACQUISITION OF COMPUTER FACILITIES

by

Jerry Larer and David Moursund
The Computing Teacher, 8(1), 1981

Many people with limited knowledge about computers are being placed in a position of helping to acquire an instructionally-oriented computer facility. This article is intended primarily for such people. It gives a broad general overview of the acquisition process in terms understandable to a person with limited knowledge about computers. If you no longer fall into this category you may still find that the article provides a useful summary and overview of the acquisition process.

A computer system consists of both hardware (physical machinery) and software (computer programs). One may purchase, lease, or lease-purchase both the hardware and the software components of a computer system. The individual hardware and software components may be acquired from a single vendor or from a number of vendors. At one time the major cost of a computer system was for the hardware. Now there are many situations in business and industry where the software for a computer system costs several times as much as the hardware. Thus software may be the dominant factor in a computer acquisition. However, the main focus in this article is upon hardware acquisition.

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Justification

The computer acquisition process begins with the identification of one or several problems which may require a computer for their solution. It may be obvious that a computer is needed. For example, a state or school district might mandate that all students are to become computer literate, and that computer literacy instruction shall include a certain number of hours of hands-on computer experience. Or, a business, math, or science text that has been adopted for a school may include a substantial unit requiring use of computers.

Typically, however, it is not so easy to justify computer acquisition. More commonly the problems that have been identified can be attacked by more than one means. For example, a school system may have test data indicating that students are weak in basic skills. There are computer programs that can be used to work on this type of problem. But there are other approaches, such as textbook selection, teacher training, increased time allocated to basic skills, etc. Why is it that computers should be used to attack this problem?

As another example, consider a social studies techer who wants his/her students to experience the situation of coping with a complicated social studies problem. The teacher is aware of computer simulations and that students enjoy working with computer simulations of social studies problem areas. But clearly there are alternatives, such as reading appropriate books, carrying on class discussions, viewing a movie, or making use of a non-computerized simulation. Why is it that computers are needed?

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Many people have given careful thought on general reasons why computers are needed in our schools. A brief summary of some of the general arguments is given in the Arguments section of this ES^3 report. Studying these general justifications can help one to understand why computers are important in education. But it is still necessary to study one's own educational setting and to carefully justify any proposed computer acquisition.

Needs Assessment

A needs assessment is a careful study of the proposed use of computers to determine the nature and extent of the facility that will be needed. Suppose, for example, that it has been decided to offer a computer science course in a high school, and that enrollment is to be limited to 20 students. The course is to include substantial use of library programs as well as instruction in a particular programming language. The library programs that students are to run will be written by the teacher in the summer before the class begins. Students in the class will need two hours of computer access per student per week. About one-third of this access must come during the time the class meets. The class meets an hour per day, five days per week.

Analysis of the above situation points to the need for a computer system with an adequate secondary storage mechanism. There will need to be a minimum of three keyboards of access (three terminals to a timeshared system or three microcomputers, for example). The facility will need to be accessible to students both during the computer science class and at other hours throughout the day.

Notice that there are many different computer systems that can meet these needs. This is a desirable situation, since it allows one to shop around for a reliable vendor who offers good service and equipment at a reasonable price.

The nature and extent of a needs assessment will vary with the complexity and size of the problem. Suppose that a school wants to acquire a very modest computer facility so that two teachers can begin to teach themselves a little about computers. The school has at most a thousand dollars to spend. It would not make sense to spend several thousand dollars of time in a needs assessment for this acquisition.

But consider the alternative of a large school district planning to acquire several million dollars of computer facility. Now the needs assessment will take many thousands of hours of people's time. The final documents, detailing the nature of the needed computer facility, may be several hundred pages long.

A very important part of needs assessment is long term planning. One's computer facility needs will change with time; likely they will grow in size and complexity. The needs assessment must address this issue. One may want a facility that can be added to via increased primary or secondary memory, new languages, more or different terminals, etc.

The results of a needs assessment can be written into a "request for proposal" (RFP). An RFP is sent to vendors interested in supplying computer facilities. It is a basis for detailed proposals offering to supply specified faciliies at certain prices. It is important that an RFP be written so that more than one vendor can meet the needs it details. This leads to competition, both in price and in the nature and quality of services offered. It is quite educational to study the proposals that various vendors will submit. The proposals may lead to a reconsideration of the needs, and possibly to a rewriting of the needs assessment. Remember that one is under no obligation to accept any of the proposals that are received.

General Financial Planning

Financial planning usually goes on concurrently with the justification and needs assessment steps. One must have some idea of how much money is available and how much various types of facilities cost in order to carry out an appropriate needs assessment. If one has only a few thousand dollars available it makes little sense to send out an RFP that can only be met by a million dollar computer system.

A common error in financial planning is to think only of the initial direct cost of the computer facility to be acquired. Here are some more thigs to think about.

1. The needs assessment, general planning, writing of specifications, dealing with vendors, evaluation of bids, supervision of installation, and so on take considerable time and expertise. Who will do this, and at what cost?
2. The acquired facility will need to be housed. What will site preparation cost?
3. Computers use supplies, such as paper, tapes, disks, and so on. Who will make sure that these are available as needed, and who will pay for them?
4. Computers need to be maintained and repaired. Who will check out the machine if something goes wrong, what provisions will exist for maintenance and repair, and who pays for this? A standard estimate is that for large computers a maintenance contract costs about.75% of the total cost of the equipment per month. This amounts to $7,500 per month on a million dollar computer system. For less expensive computer systems, such as microcomputers, perhaps 2% per month is a reasonable estimate of potential maintenance and repair costs beyond the first year.

5. Large computer systems require operators and usually require a programming staff. Such staff can easily cost as much as the rental of the computer system they are operating.

6. Teachers may need to be trained, curricula may need to be revised, courseware may need to be developed.

7. Software may need to be revised, developed, or acquired. The software will need to be maintained and distributed. Over the long run this can easily cost more than the original cost of the computer facility. Who will do these things, and who will pay for it?

The list could be expanded, but it is already long enough to make the point. One should make an estimate of the useful life of the equipment to be acquired and of all expenses associated with this life. The amount of "up front" money needed may be quite modest compared to the overall expense. Can one justify the overall expense?

The Acquisition Process

Renting or purchasing computer equipment through a school district is generally subject to a considerable amount of red tape. Approval may need to be gained at the school building level, the school district level, and at some higher level such as an educational service district or state level. The procedures to be followed in preparing specifications and going out for bids often have to meet rules laid down by various regulatory agencies.

We can offer two general types of advice here. first, enlist the aid of appropriate administrative personnel in completing the paperwork and procedures required by the various levels of school districts. Second, handle the overall request for bids in a relatively formal and professional manner. The larger the acquisition the more care needs to be spent on both points.

There can be a considerable financial gain to preparing careful specifications and going out for bids from a number of vendors. This is true even if you have decided that there is only one brand of equipment that will meet your needs. If there is more than one vendor of this brand of equipment there can be competition. If there is competition for the contract there is likely to be price cutting. Of course if you are purchasing a single $600 microcomputer you can't expect much concession from a dealer. But if you are purchasing $25,000 worth of microcomputers you may well be able to get a 10% to 20% discount. If you are acquiring a million dollar computer system and a particular vendor is very eager to get your business you may well get a larger discount.

Knowledge About Computers Versus Size of Acquisition

For convenience in the remainder of this presentation we divide people into three categories, based upon their knowledge and experience in the computer field.

1. People with a modest or very low level of knowledge about computers.
2. People with a medium amount of knowledge about computers.
3. People with considerable knowledge about computers.

It is not important to give precise definitions to these three categories. However, a person who has had formal coursework and/or experience equivalent to only one or two computer courses or less is probably in the first category. Professionals, with knowledge and experience equivalent to a master's degree in computer science or more, are in the third category. You can decide for yourself which category best describes you.

It is also convenient and instructive to divide computer acquisitions into three sizes.

A. A small acquisition, such as a few microcomputers or a corresponding amount of timeshared computer facility.

B. A medium acquisition, perhaps for a single large school or for a small small school district. This could well range from $5,000 up to $100,000 in magnitude.

C. A large acquisition, perhaps to meet the needs of a large school district or a statewide educational organization. The amount of money involved could range up into the millions of dollars.

[2] The exact dividing lines between categories are not important.

Taken together the two sets of classifications form a three by three matrix.

		Size of Acquisition		
		Small	Medium	Large
Knowledge & Experience	Low	1A	1B	1C
	Medium	2A	2B	2C
	High	3A	3B	3C

Suppose, for example, that you are in cell 1C of the matrix. You know relatively little about computers but you are considering a large acquisition. You should see the obvious ... that this is not a good situation. At the other end of the scale consider a 3A person. Such a high knowledgeable person does not need the aid of this short article to make a small acquisition. The main advice offered in the remainder of this article will focus upon the categories 1A, 2B and 3C

Advice to Level One People

Level One people have little or no knowledge about computers. It is doubtful if a Level One person can do an adequate justification and needs assessment for the 1B or 1C situation. Thus if you are in the 1B or 1C situation you should probably do three things. First, start studying the computer field. Second, hire a professional consultant. Third, involve other educators from your school district in the overall task.

In hiring a consultant use common sense. Find one who is experienced, who doesn't have a particular ax to grind, and who can produce good references. (A particular consultant may have a predisposition towards acquiring a particular vendor's equipment or have other biases of this sort.) Remember that you are intending to spend a good deal of money in a field about which you know next to nothing. You will be highly dependent upon the consultant. You should be prepared to spend a significant amount of time in selecting a consultant, and a significant amount of money in hiring the consultant. Also, you will need to continue to learn more about the field, and to carefully study the consultant's work.

Suppose that you are in the 1A category. You don't have much money to spend, you have limited knowledge, and (hopefully) you have limited goals. There are two general categories of equipment available to you. You might tie into an existing timeshared educational computer network. Or, you might aquire one or more microcomputers. A very good thing to do is to find several people who have similar goals and who have already acted to start reaching the goals. If timeshared computing facilities are a viable alternative then you should be able to find several educators who are using the system. Talk to them, and seek their advice. Are they satisfied with the service, and is it solving their problem?

If microcomputers appear to be the answer, find some teachers using microcomputers in a setting somewhat similar to the one you envision. If at all possible try to view several different brands of machines in use.

Overall what you are doing is trying to make use of a free consulting service. Each person you visit and talk to is a consultant. Be aware that they are likely to be biased (it could be towards or against their current equipment) and likely do not have a broad general overview of the range of potential solutions to your problem. However, likely they are interested in helping you solve your problem and may well contribute substantial time to helping you. They may be able to provide you with inexpensive or free access to software that you will need.

In this search for "free" consultants you may well want to talk to vendors. But be sure to talk to some nonvendors. Also, be aware that a vendor is particularly interested in solving your problem with the type of equipment that he/she sells or rents.

In summary, you are making a rather limited acquisition. Thus you will likely put a rather limited amount of effort into it. Whatever your decision, acquire only something that already exists and which you can both see in action and try out before hand. Do not be the pioneer. As a rank amateur you should be following in others' footsteps.

Advice to Level Two People

Level Two people have a medium amount of computer knowledge and experience. If the problem you face is of type 2A then you have adequate knowledge to solve it. Indeed, the 1A people will be coming to you, and will think of you as an expert. Still, you know that you are not an expert. Thus you will want to do a careful needs assessment and a careful study of the range of potential equipment. This can be a valuable learning experience, and it can be fun.

We need to say a little more about what distinguishes a Level A from a Level B or Level C acquisition. At the B and C levels one needs very careful long term planning. The maintenance and repair budgets will be substantial. Quite a bit of equipment needs to be housed. There will be many users, so there is need for quite a variety of software. The computer will be used in many courses, so many teachers need to be trained and much curriculum revision is necessary. A classroom teacher, no matter how knowledgeable, is not in a position to cope with these problems. Central administration must be involved.

At the 2B level a school or school district should consider release time for a teacher who is to be the computer expert. The types of activities listed above can easily be a half time or full time job, depending upon the amount of equipment that is to be available, the number of teachers to be trained, the amount of curriculum work to be done, and so on. If a school or district is not willing to make this sort of staffing commitment it is not clear that they should acquire the computer equipment.

The 2C situation again calls for outside help. As a very rough rule of thumb when one is considering a medium scale computer acquisition one should think of spending perhaps 10%-20% of the cost of the proposed equipment in the overall acquisition process. That is, for a $30,000 acquisition you might put in $3,000 to $6,000 of people's time doing the needs assessment and studying the range of equipment that might be acquired. For a large scale acquisition one might spend 5%-10% of the cost of the equipment in the study. Thus acquisition of a million dollar computer system might be backed up by $50,000 or more of people's efforts. A needs assessment and study on this scale requires several people and quite a long time span. It is too large a burden to place on a single individual--especially one with only a medium level of computer knowledge and experience.

When following the above general guidelines you should be aware that substantial amounts of people's time can be available at no direct added cost. The proposed users of a computer system can do quite a bit of the needs assessment as part of their regular job, and/or as part of their discretionary workload. But the overall coordination of the task can be quite time consuming and is not readily done by a person who is carrying a full time workload as a teacher or administrator of other projects.

Finally, be aware that the percentage guidelines are very rough and may not apply to your situation. Suppose your school district intends to acquire 500 identical microcomputers. The effort going into this project will not be too much larger than that needed to acquire 50 identical microcomputers.

Advice to Level Three People

The Level Three person is likely a computer professional, working full time in the computer field. This person has no trouble with the 3A acquisition, and can easily head up a 3B acquisition given the necessary time. We will restrict our attention to the 3C situation.

Over the long run it appears that education will be best served by a distributed computing system. This will be a combination of a centrally located timeshared computing system and distributed microcomputers and/or minicomputers that can serve as intelligent terminals and also as stand alone systems. Many instructional tasks can be accomplished on a microcomputer, and the capabilities of these machines will continue to grow rapidly over the next five to ten years. However, many instructional tasks require access to very large data bases, very large primary memories, very fast CPUs, etc. The communication aspects of timeshared computer systems are critical to some applications.

The design and development of an appropriate educationally oriented distributed computing system is a difficult task. Although some progress has occurred in higher education computing networks and in the Minnesota Educational Computing consortium network, this type of progress tells us relatively little about what a public school system should be doing. Thus a person in the 3C situation is faced with a substantial research and long term planning project. Outside consulting help, support of a strong staff, and plenty of time to devote to the project are all highly desirable.

A school district that commits itself to having a substantial amount of computing equipment should also commit itself to providing a substantial amount of money for continuing "people-oriented" support of the system. Every year new teachers will need to be trained and teachers who have previously been trained will need to refresh or upgrade their skills. There will be a continuing need to develop or acquire new software, revise and improve curriculum, and so on.

Many school districts currently make extensive administrative use of computers, and the amount of instructional use of computers is growing rapidly. Currently a school system making extensive administrative and instructional use of computers may be spending 2% of its budget in this area, with approximately equal expenditure in the two categories. If teahing about computers and teaching using computers continues to increase in importance then one can expect that this 2% percentage figure will prove to be quite inadequate. A school system needs to give careful thought before it commits itself to the long term continuing expenditure of such amounts of money.

Conclusion

The acquisition of instructional computer facilities can be a difficult and time consuming task. It is best done by people with quite a bit of knowledge about computers who have had experience in computer acquisition. But there are relatively few such people working in the precollege educational environment. Thus most schools and school systems that intend to acquire computers do not have staff with the needed level of expertise.

This article offers some suggestions. Above all, use common sense! A computer system, once acquired, will be with you for many years. You will invest much money in teacher training, software development or acquisition, and curriculum development. Much of this cost will be specific to the particular type of equipment you acquire. That is, much of your expenditure may be wasted if you suddenly decide to get rid of the equpment you have and acquire a substantially different type of gear. Thus equipment acquisition should be based upon a very careful needs assessment and planning that looks well into the future.

References

Many computer-oriented magazines and journals carry reviews of computer hardware and software. If you are considering a major acquisition of microcomputers you would be well advised to take a look at the latest Microcomputer Report of the Minnesota Educational Computing Consortium. The 1979-80 report was about 90 pages long and sold for $10 to Minnesota educators, $13.33 to people outside of Minnesota. Write to MECC, 2520 Broadway Drive, St. Paul, MN 55113. Another excellent source of information on microcomputers is the AEDS Journal, V 13 #1, Fall 1979, Special Issue on Microcomputers: Their Selection and Application in Education. The cost is $10 from AEDS, 1201 Sixteenth St., NW, Washington, DC 20036.

MANAGEMENT APPLICATIONS OF THE MICROCOMPUTER: PROMISES AND PITFALLS

by

John E. Haugo

Association of Educational Data Systems, 14(4), Summer 1981

Abstract

The rapid advances in microcomputers have made many educational applications feasible which formerly were performed on large-scale systems. Initial applications have been primarily instructional in nature. This paper will deal with potential management applications of the microcomputer, applications which relate to financial, personnel, and student information systems. Primary emphasis will be on the relative advantages and disadvantages compared to large computer systems and manual record-keeping processes. Alternatives for the development and support of microcomputer-based management systems will be discussed.

(Keywords: administrative computing, microcomputers.)

The availability of a variety of microcomputers over the past several years has created a great deal of excitement among educators in the United States. The new computers have offered an opportunity to learn new aspects of computing at a low cost. As the microcomputer has begun

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Editor's Note: This article is based upon a paper presented by the author at the annual meeting of the Association for Educational Data Systems held in Minneapolis, Minnesota, in May, 1981. Dr. Haugo received the AEDS Best Paper Award in the Administrative Category for his presentation.

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to be used by persons who work closely with users of more traditional educational computing systems, these persons also began to develop programs to show selected capabilities of the new devices. The use of microcomputers in school districts has led to an increased awareness among many school district administrators of the processing capabilities of computers. Interest has been expressed in using microcomputers to handle some administrative activities, particularly in small districts and in individual schools in large districts.

As educational administrators have gained some familiarity with microcomputers, opinions as to the potential value of computers for management tasks have become more prevalent, and more extreme. Claims have been made at both ends of the continuum. Some say that microcomputers are capable of handling all of the management computing needs of small districts and schools, while others say that they are appropriate only for instructional computing needs. However, most educators who have an awareness of the microcomputers see potential for their usage as management tools and are asking for more iformation about applications that might be feasible.

In the private sector, the use of microcomputers for administrative purposes has increased significantly during the past year. Microcomputer company sales and projections show that small business use of microcomputers is going to be an increasingly large portion of the market. Tandy, Apple, and Commodore have all recently enhanced their microcomputer configurations to accommodate small business data processing applications. During the past several years, literally hundreds of versions of microcomputer-based applications such as general ledger, accounts/receivable, accounts/payable, and inventory have been developed for the small business user.

During the past year, the Minnesota Educational Computing Consortium (MECC) has explored several approaches in the use of the microcomputer as a management tool. Initially they developed the interface between a large host computer and an Apple II microcomputer. The Apple II is used as a remote data collection device which edits, stores, and transmits the data to the host computer. This approach reduces the load on the host and on the telecommunications network. MECC also has worked with several school districts on the development of stand-alone management applications.

A recent directory of Apple software (Vandiver & Love, 1981) includes a section on the school administration applications. Among the 22 available applications for the Apple II are attendance, class scheduling, school bus routing, fixed asset inventories, and central activity accounting. Prices vary from less than $20 to more than $400 per application.

A number of publishing companies have announced microcomputer-based school management applications. The most common application is a course on instructional management systems which relates to specific textbook series. Recently, Scott, Foresman and Company announced a comprehensive set of school management applications (Scott, Foresman and Company, 1981). The applications which are developed to operate on the Texas Instrument 99/4 microcomputer relate to a variety of student, personnel, and financial functions. The 15 applications are grouped or packaged to be utilized at the district, school, or classroom level.

Feasibility of Microcomputer-Based Management Applications

During 1979, there were two efforts to determine the feasibility and/or interest in school management applications of the microcomputer. Education Turnkey Systems, Inc. (1979) of Washington, D.C., through its Microcomputer Education Application Network (MEAN) surveyed educational administrators at several national conventions. They determined that there is a high level of interest in educational and administrative applications of the microcomputer. The preliminary findings of their survey showed that there was significant interest in a number of applications, including: monitoring of individualized special education programs, test scoring and analysis programs, Title I report generator, computerized curriculum guides, student scheduling, attendance, equipment/materials inventories, and grade reporting.

The second study of feasibility and interest in administrative users of the microcomputer was conducted by the Minnesota Educational Computing Consortium (MECC, 1979). Because of the widespread availability of Apple II's in school districts in Minnesota, there was interest in using them for management purposes.

The MECC study team used a variety of data gathering techniques including site visits at school districts who were using the microcomputer for school management purposes, usage data gathered by regional MECC coordinators, interviews with school superintendents, visits with small business microcomputer users and computer vendors, and a thorough analysis of existing time-sharing or microcomputer administrative software. General findings regarding the technical feasibility were:

Processor speed. Compared to large computers, microcomputers are slow and can handle relatively small amounts of data. However, for most of the potential applications explored in the study, speed was not critical. Also, for many applications (such as payroll) the number of records needed is in the range of 100-200. For most potential applications, processor speed seems to be adequate.

Memory. It is estimated that for most of the potential applications, 32K of random access memory internal to the computer is adequate. the memory can be expanded to 48K with the purchase of 16K of memory for a relatively small price. The additional memory decreases processing time for some applications, such as those requiring extensive sorting.

Input. Several input modes are possible for the microcomputer. A user may utilize the keyboard, punched cards, mark sense cards, cassette tape, diskette, or a downloading connection from another computer system.

Disk storage. Multiple disk drives can be connected to most microcomputers. Each disk drive allows storage of up to 116,000 characters that can be retrieved through random access. Up to 1200 records of 80 column length can be stored on one diskette.

Output. As with input, several output modes are possible with microcomputers. A user may utilize a hard copy printer, a television screen, a video monitor, a disk drive, or a cassette tape. Output speeds varying from 30 characters per second (cps) to 120 cps are possible.

Reliability. The reliability of microcomputers is at this point an unknown. While we have no indication of major problems which can cause the frequent loss of data, occasional problems can be expected to occur. Back-up equipment and procedures can considerably reduce the risk of data loss. At this time, microcomputers have not been around long enough to adequately assess reliability.

Potential Applications

In determining a list of possible microcomputer-based school management applications, it is necessary (a) to examine those which currently are available; (b) to identify applications used in the business sector which have applicability for education; and (c) to discuss potential applications with persons who have expertise in both school management and computer technology.

As a result of this approach and based on the aforementioned technical feasibility considerations, the following is a list of potential applications by area.

Student:
1. Athletic Eligibility List
2. Attendance (annual)
3. Attendance (daily)
4. Class Records
5. Census (family)
6. Enrollment Projection
7. Graduate Follow-Up
8. Guidance Records
9. Health Records
10. Instructional Management
11. Mark Reporting
12. Scheduling Assistance
13. School Calendar
14. Student Records
15. Test Scoring and Analysis

Personnel:
1. Paycheck Calculation
2. Payroll Reporting
3. Personnel Record
4. Salary Simulation
5. Staff Assignments

Facilities:
1. Energy Management
2. Facilities/Equipment Inventory
3. Facilities Utilization
4. Maintenance

Finance:
1. Accounts Receivable/Payable
2. Activity Accounting
3. Financial Forecasting
4. Food Service
5. General Accounting
6. General Ledge
7. Investment Accounting
8. Vendor Reports/ Purchase Orders

General:
1. Activity Scheduling
2. Ad Hoc Reporting
3. Bus Routing
4. Information Storage and Retrieval
5. Library Circulation
6. Media Reservations
7. Mailing Lists/Labels
8. Project Planning and Budgeting
9. Statistical Analysis
10. Snow Removal Schedule
11. Word Processing

Comparative Considerations

In the use and allocation of any educational resource, it is necessary to make some tradeoff decisions concerning alternatives. In the case of the use of computer-based management applications, some of the considerations favor the use of manual administrative systems, other favor large systems, and still other factors favor microcomputer applications.

The following is a list of some of the advantages of microcomputer-based management applications:

Equipment cost. A microcomputer with 48K, dual disk drives, card reader, and a printer can be purchased for less than $5,000.

Ease of implementation. A school district can get started with a microcomputer with very little investment of time, effort, or money.

Ease of operation. Microcomputers are relatively easy to operate; as such, highly trained technicians are not required.

Flexibility. The school user can achieve the capability of down-loading or extracting portions of a district's data base from a large computer to a microcomputer.

Multi-purpose use. The same microcomputer can be used for administrative and instructional applications. By having multiple units within a district, there would be backup in the event of equipment problems.

Software cost. The cost of purchasing commercially developed programs for microcomputers is much less than programs for larger computers. Programs for microcomputers can be sold in much large volume than can programs for larger computers, and they are typically less complex.

User control. The local school district can own the equipment and therefore completely control its use and operation.

The disadvantages of using the microcomputer for school management applications are:

Available software. Most current administrartive programs have been developed for large computers. There are very few administrative programs with documentation currently available for microcomputers.

Difficulty of application development. It is relatively easy to develop fairly simple programs for microcomputers; however, more complex programs, in particular those that make extensive use of files and require extensive data manipulation and updating, are difficult to develop on a microcomputer.

External reporting. As compared to larger computers, meeting external reporting requirements is more difficult with stand-along microcomputers because of the limited data-base storage.

Integrated applications. Due to the limited size of core and mass storage, it is not feasible to develop integrated data-base systems by using microcomputers.

Limited usability. Some management applications require large computers to run (computer scheduling of students, large sorts, large volumes of data storage) and are not amenable to small computers.

Operational responsibility. District staff are responsible for hardware operation and maintenance; for securing or supplying hardware; and for software selection and maintenance.

Reliability. Reliability of data storage on diskettes commonly used with microcomputers is still problematic.

Development and Support

Traditionally, the development of computer applications and support services to end users have been provided by computer services staff who are part of the same organization. They typically have been staff at the local school district level for those school districts large enough to operate their own main-frame computer and its staff. Recently, some states and/or regions have developed software for use on a large computer. The operations and user staff have been affiliated with another level. For example, in Minnesota administrative software has been developed at the state level by MECC; however, the operation of the service centers and the end user support have been provided at the regional level. As microcomputers become more capable, it is obvious that the actual operation will be at the local school level. The question remains as to who will develop and support the software.

In terms of system development, it is likely that software will be developed by a number of entities. Local school personnel will design and program some of their own applications software. However, this can prove to be quite costly, since the time required to design, program, and test comprehensive systems (e.g., financial accounting) for microcomputers is the same as for large computers. Regional and state systems development teams will also be involved with the design and development of microcomputer-based management applications. Software firms, computer vendors, and publishers of electronic materials are also likely to get into the act. Because this type of software will be a high volume, low unit cost product, it will typically take a relatively large distribution base to market it profitably. As these software products are "packaged," they necessarily must be generalized in order that a wide variety of users will be able to utilize them. Users, therefore, will have to forfeit some of their flexibility. With the economies of the situation, it may be a matter of obtaining 90% of the features of an optimal system versus not having access to computerized management systems.

In the future, users of microcomputer-based management applications will likely receive support services in the form of training, trouble shooting, and other user services from a variety of sources. In addition to local district services staff, there will be regional, and perhaps even state, support staff. Those new participants in the software development business--the vendors and publishers--will provide training workshops and seminars, hot line services and thorough user manuals. However, end users will have to be more self-reliant than they have been in the past.

Even with need for more knowledgeable, self-sufficient users, because of the service advantages and the economies of scale, we are likely to see widespread use of microcomputer-based applications for school management purposes in the not too distant future. As a result educational decision-makers will be able to cut costs and increase management productivity.

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EXCERPTS
from
A DESIGN FOR THE EVALUATION OF MANAGEMENT INFORMATION SYSTEMS

by

Dennis W. Spuck and William C. Bozeman
AEDS Journal, 14(1), Fall 1980

Because of the role computers have taken in business, industry, and our daily lives, technology associated with information management and decision making has received considerable attention during the past decade. Although the concepts and principles of information management are not new, the advent of low-cost, high-speed data processing facilities now provide managers with resources which were not feasible a few years ago. The basis for the rapidly evolving field of management information systems (MIS) comes as a result of this availability combined with increasingly complex management functions.

Planning and Design of a MIS Evaluation System

The evaluation of management information systems assumes many forms depending on the different purposes or functions which the evaluation effort addresses. These differences are influenced by (1) the various personnel roles inherent in an organization, (2) the perceived needs for the MIS, (3) the different levels of personal involvement and varying personality/psychological types, and (4) differing levels of technical expertise.

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The functions of a total MIS evaluation system also vary over time as they span a total MIS life cycle from initial planning to actual implementation and operation.

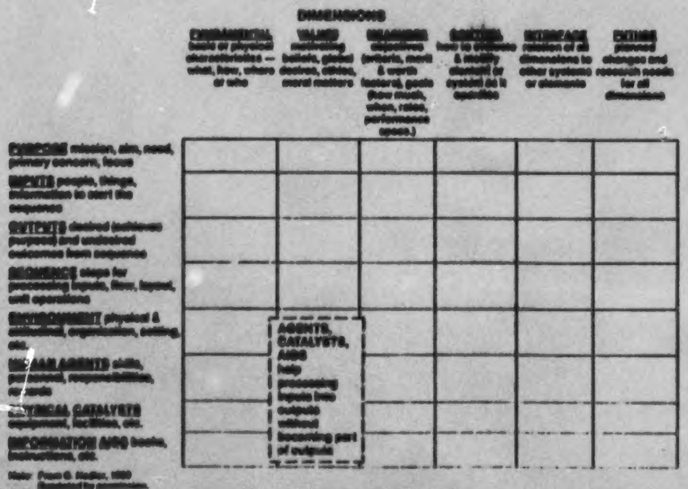
The authors suggest use of a generalized framework and procedures which can be adapted to most MIS evaluations. This framework is comprised of four important principles:

1. A prescriptive definition of the term "system."
2. The meaningful involvement of persons within the organization who have an interest in the MIS.
3. Consideration of both objective (quantifiable) evaluation data and subjective (qualitative) information.
4. A program for ongoing modification and improvement of the MIS.

These four principles are addressed in the following sections.

System Definition. A system framework is used as a foundation for defining the various components of an MIS. The framework used must meet criteria of descriptiveness, completeness and understandability by the user. It must also be capable of capturing the basic design and operational characteristics of the MIS as a whole. The authors suggest as a framework the system matrix (Nadler, 1980) shown in Figure 1 as most appropriate for the evaluation scheme presented.

Figure 1: System Framework


DIMENSIONS
FUNDAMENTAL basic or physical characteristics — what, how, where or who
VALUES motivating beliefs, global desires, ethics, moral matters
MEASURES objectives (criteria, merit & worth factors), goals (how much, when, rates, performance specs.)
CONTROL how to evaluate & modify element or system as it operates
INTERFACE relation of all dimensions to other systems or elements
FUTURE planned changes and research needs for all dimensions
PURPOSE mission, aim, need, primary concern, focus
INPUTS people, things, information to start the sequence
OUTPUTS desired (achieve purpose) and undesired outcomes from sequence
SEQUENCE steps for processing inputs, flow, layout, unit operations
ENVIRONMENT physical & attitudinal, organization, setting, etc.
HUMAN AGENTS skills, personnel, responsibilities, rewards
PHYSICAL CATALYSTS equipment, facilities, etc.
INFORMATION AIDS books, instructions, etc.
AGENTS, CATALYSTS, AIDS help processing inputs into outputs without becoming part of outputs

Note: From G. Nadler, 1980
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Involvement of People. The operationalization of this framework represents a means of achieving the second principle--meaningful involvement of persons within the organization who have an interest in the MIS and who are concerned with the overall MIS evaluation effort. The authors recommend the use of project teams composed of persons concerned with specific aspects of the system. The objective is to ensure that concerned persons with differing perspectives are involved in the system evaluation just as they would have been involved in system design and implementation. The initial phase of the evaluation procedure, therefore, involves the analysis of the system by the project teams using the system framework.

Evaluation: Systems, Elements and Dimensions

The eight elements shown in the system matrix (Figure 1) provide the direction for formulating an evaluation design. Of primary importance is system purpose; this combined with system output points to system effects (that which is to be accomplished through system operation).

In MIS, the output is information, while the purpose of the system may be to improve decision making and ultimately improve the effectiveness and/or efficiency of the organization. Emphasizing MIS output focuses attention on the following concerns of evaluation:

- the determination as to whether the system can produce desired reports
- the examination of whether (or to what extent) that output is used
- the investigation of the extent to which the use of that information affects organization decision making and productivity

Both intended and unintended effects are of interest in system evaluation.

Evaluation Framework

Primary purposes for the evaluation of a management information system are to assess the extent to which the goals and objectives of the system are being realized and to identify factors associated with successful and unsuccessful outcomes. Accomplishment of these purposes can and should lead to change and improvement of the MIS. Building upon the system framework presented in the previous section, it is possible to identify the key elements associated with system success. Focus on those elements during system evaluation may provide information useful in refining system design and implementation, thereby increasing the likelihood of system effectiveness when implementation is completed.

To assist in the evaluation of management information systems, an evaluative framework has been developed. This framework, shown in Figure 2, contains three dimensions of evaluation--functional, utilizational, and effect. The functional dimension is concerned with whether or not the various subsystems of the MIS (human, hardware and software) are capable of operating or functioning in accordance with design expectations. It is assumed that design specifications reflect actual need and that these specifications are sufficiently explicit to allow for assessments of system functioning.

System utilization is concerned with (a) the analysis of those management processes for which the system is being employed and (b) whether or not this use is consistent with those specified in the system's design. System uses which are different from those specified in the design are not immediately interpretable as a problem, as users frequently find creative and productive new uses of systems. Lack of use always constitutes a problem, the roots of which typically reside in inadequate system design or poor planning for implementation--the criteria used as the basis for the evaluation of system functioning. As is probably evident, system utilization is dependent upon system functioning. In a like manner, system effectiveness is dependent upon both functioning and utilization. Assessment of functioning and utilization thus provides important intermediate criteria for the evaluation of system effectiveness.

System effects should directly reflect MIS purposes and goals--what results are being achieved as a result of MIS utilization and are the objectives of the system being met? For example, in public educational institutions goals ultimately include reference to changes in student behavior or student achievement. While objectives pertaining to changes in student behavior should not be ignored in the evaluation of MIS, it frequently is difficult to establish a direct linkage between MIS implementation and changes in student variables. Other factors may have to be examined, such as changes in the way teachers or administrators use time, or judgments concerning the system's value in improving decision making could be assessed.

The distinction between directly observable system effects and user descriptions of system effects leads to the second dimension of the evaluation model--the type of information available for system assessment. Information type is classified as actual, perceptual and attitudinal. Actual information is objective, derived from data which are generally observable and quantifiable.

Figure 2: Evaluation Framework for a Management Information System

DIMENSIONS LEVELS	**FUNCTIONAL** Are the various subsystems of the MIS program, both human and physical, capable of operatingor functioning in accordance with design specifications?	**EFFECTS** What results are achieved from the utilization of the system, and are the objectives of the system being met?	**UTILIZATION** For what management processes is the system being employed, and is the use of the system consistent with those uses specified in the design?
ACTUAL Objective and/or quantifiable information from primary source			
PERCEPTUAL User descriptions and awareness of system operations and effects			
ATTITUDINAL User conclusions about value or benefit of the system			

Perceptual information is derived from user descriptions or perceptions of system operations and effects. Assessment of direct system effects on student achievement or system efficiency thus constitutes actual information, while description of perceived changes in student behavior or usefulness of information are perceptual information. Generally, actual information is better for evaluating system functioning, utilization and effect, but comparisons between actual and perceptual information can be of value in identifying problems in system operation, and in some cases the collection of actual information may be more difficult or costly than perceptual information.

The last category of information is attitudinal. Attitudinal information, comprised of user conclusions or judgments about the value and benefit of the system, may include personal and intuitive feelings of the user toward the system, including expressions of user apprehension, anxiety and satisfaction.

The three dimensions of evaluation and three levels of information, when considered together, comprise a nine-cell matrix, as illustrated in Figure 2. In the next section an example of the application of this model to the evaluation of a particular management information system will be presented.

An Instructional Management Information System

There has been no scarcity of literature related to the management of individualized education during the past few years. Educational journals are replete with numerous approaches to this problem. Several of the serious investigations into individualization have produced well-known products such as Individually Guided Education (IGE), Planning for Learning in Accordance with Needs (PLAN), and Individually Prescribed

Instruction (IPI). These programs and similar ones are utilized by thousands of teachers throughout the nation.

Although several models of individualization exist, most current programs are based on enrichment and acceleration. In such models, there are series of activities and tests which are followed in a sequential pattern. Some diagnostic models also employ pretests to assess achievements before beginning instruction. Other models (e.g., IGE) employ grouping procedures for instruction wherein students at a given mastery level study topics deemed appropriate by the teacher.

This perceived need by educators to individualize instruction has contributed to the development of systems of computer-managed instruction (CMI). Closely associated with these programs of individualization has been a significant increase in the requisite record keeping and clerical tasks. Student progress is typically monitored more closely than in traditional instructional environments, resulting in greater demands upon the teacher with regard to record keeping, planning, and decision making. Even the inherent nature of decision making is altered, as planning becomes oriented to smaller groups or individuals rather than entire classes.

Another factor which has contributed to the development and utilization of CMI systems has been the increased availability of computing power. The past decade has witnessed a dramatic reduction in computing costs as well as widespread implementation of data processing centers or networks for small to medium size school districts.

To avoid possible confusion, some distinction should be made between computer-assisted instruction (CAI) and CMI. One important difference between CAI and CMI is the degree of direct interaction that the student

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has with the computer programs (Bozeman, 1979; Fromer, 1972; Thomas, 1979). CAI is typically a curricular program in which an interface exists between student and computer for the purpose of instruction. This interface is accomplished by student communication with the computer via a terminal. Presentation and sequencing of materials is, to some extent, controlled by the computer.

In contrast, in CMI systems direct student interaction with the computer is limited or many times non-existent. CMI systems may, therefore, be considered computer-supported management information systems designed to support the management processes or functions associated with programs of individualized education. Of particular importance within any CMI system is the support of decision making. CMI systems seek to facilitate the processing of information and supplying this information so that it can be applied directly to instructional decision making (Spuck, Bozeman & Lawrence, 1977). Major efforts in the development of CMI systems have been conducted by Boeing Computer Services Company for use primarily in industrial and manufacturing settings, by McDonnell Douglas for use in Air Force training programs (Yasutake, 1974; Mayo, 1974), by the United States Navy for use at the Naval Air Technical Training Center (Johnson & May, 1974), and by several educational research and development centers and school districts (see, for example, Spuck, Bozeman & Lawrence, 1977; Roecks, 1979; Wang & Fitzhugh, 1977).

An illustration of the framework applied to the evaluation of an instructional management information system is given in Figure 3. The purpose of this system is to provide information which will improve instructional decision making in the implementation of individualized instructional programs designed to maximize the attainment of program objectives. At the same time, teacher time consumed in record keeping, in diagnosing student learning needs and in formulating instructional strategies for meeting these needs should be reduced to allow more time for instruction and preparation. Criteria directly related to these objectives are outlined under the dimension of effects. Student achievement data, teacher time usage, system cost, and changes in roles and tasks, being directly measurable or observable, are listed in the row labeled "actual," while teacher descriptions of system impact on achievement and decision making are classified as perceptual. Judgments and attitudes toward perceived system effects and overall user satisfaction are included in the evaluation framework in the row denoted as attitudinal information.

System usage and attitudes pertaining to system use are listed in the column headed "utilization." Typically, management information systems are constructed so as to maintain by user account number a log of accesses and report requests. Such information is helpful in monitoring system utilization. Reasons for limited requests for certain reports and uses of requested reports may be investigated. A utilization indicator such as "system responsiveness" may be assessed directly through log data, such as the time between report requests and delivery of the report, and this figure can be compared with external criteria for responsiveness. But responsiveness may also be addressed through user descriptions of whether or not delivery of reports was timely with respect to user needs. Descriptions of report usefulness and appropriateness are two additional perceptual indicators of utilization. The attitudinal level is represented by expressions of user confidence in the system and feelings about the usability of the system.

Figure 3: Evaluation Framework for CMI

DIMENSIONS / **LEVELS**	**FUNCTIONAL** Are the various subsystems of the MIS program, both human and physical, capable of operatingor functioning in accordance with design specifications?	**EFFECTS** What results are achieved from the utilization of the system, and are the objectives of the system being met?	**UTILIZATION** For what management processes is the system being employed, and is the use of the system consistent with those uses specified in the design?
ACTUAL Objective and/or quantifiable information from primary source	1. Computer software testing 2. System response time 3. Required hardware available 4. Appropriate user interfaces (e.g., error messages) 5. User knowledge of system operations 6. System availability 7. User documentation and training materials	1. Number and type of system accesses 2. Uses of system reports 3. System responsiveness	1. Student achievement 2. Teacher time usage 3. System cost and cost effectiveness 4. Changes in roles and tasks
PERCEPTUAL User descriptions and awareness of system operations and effects	1. Need for MIS perceived by user 2. Perceived level of administrative support	1. Descriptions of usefulness of system reports 2. Appropriateness of reports 3. System responsiveness	1. Descriptions of impact on achievement 2. Perceptions of system
ATTITUDINAL User conclusions about value or benefit of the system	1. Initial apprhension or anxiety 2. Potential utility 3. Personal commitment	1. Confidence in system accuracy and reliability 2. Feelings concerning system usability	1. Desirability of system effects 2. User satisfaction impact on decision making

Prior to system utilization, assessments should be made of whether the various components of the system are capable of functioning as specified. In a system of computer-managed instruction this testing includes questions about hardware and software requirements as well as personnel and training materials. For example: Do teleprinters located in the school buildings have a capacity sufficient to print the anticipated volume of reports? Are error messages sufficiently clear to allow for user correction of system requests? Are users able to interpret, understand and use the information contained in reports generated? At the perceptual level, two examples are presented: perceptions of the need for MIS support on the part of teachers and administrative commitment to this application. Initial attitudes which may be useful in planning for user training sessions or for successful system utilization are feelings of anxiety, potential usefulness of the proposed system, and the level of personal commitment to implementing the system.

The actual entries in the evaluation framework, of course, are application-specific and require the statement of explicit evaluative criteria. The elements and dimensions of the systems matrix are helpful in generating evaluative criteria, and the source and nature of information collected determine the level at which it is classified. Classification after the fact is not the major function of the framework, but rather it is to remind the evaluator that both types of information may be useful and that the interpretation of the levels of information differ. Actual information identifies actual levels of system capability or operation, while perceptual information is filtered by the attitudes, values, and knowledge of the person providing the perception. Differences between actual and perceptual indicators may suggest that user understanding of the system is limited, that the system in some way violates existing norms or values, that users are dissatisfied, or that system specifications are at variance with user needs.

Conclusion

This paper has presented a model for the evaluation of management information systems. Three levels of information considered were actual, perceptual and attitudinal, and the dimensions of evaluation discussed were functional, utilization and effects. The three dimensions of evaluation are seen as hierarchical, in that utilization is dependent upon functionality, and positive effect is dependent upon utilization. The functional dimension is concerned with whether the various subsystems of the MIS are capable of operating in accordance with design specifications. Utilization focuses on the management processes for which the MIS is being used, and the effects dimension includes the results which are achieved through system use, whether intended or unintended. While the evaluation framework presented is more general than its application to MIS, the model is tailored to this application through an example of instructional management information systems.

Evaluation is an ongoing process, conducted in conjunction with system needs assessment, planning, design and implementation. As an integral part of these procedures, it provides information which will support system modification to meet better the needs of the organization and its members. The need for system modification may result, for example, from changes in personnel, from internal reorganization, from changes in organizational goals or from variance between what is planned and what is able to be implemented. Formative evaluation strategies provide the information base to support adaptive changes as well as longer term decisions concerning the value of the system, its effects, and whether or not it should be continued or expanded.

Contributors

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STATE-OF-THE-ART REPORT

COMPUTERS AND THE HANDICAPPED

by

Melinda Lindsey
Jackson County ESD, Medford, Oregon

August 1981

Documentation and report of a Regional Study Award
Northwest Regional Educational Laboratory

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When I was informed earlier this year that the supplies and equipment of my resource room would be augmented by an Apple II Plus Microcomputer, I was delighted. Without any programming skills and lacking even the barest understanding of microcomputer terminology or capabilities, I envisioned my students receiving instruction and practice in all basic skills from a machine that was eminently patient, persevering, and as skilled as I in error analysis, diagnosis, and remediated. My delight turned to dismay when I asked for information about available programs and was given a small number of catalogues and magazine advertisements. Instead of the wealth of well-designed instructional programs, neatly organized by content area and with detailed descriptions of the programs, I found an enormous quantity of titles, described in one or two lines in jargon that was not always comprehensible, none designed specifically for handicapped students, and only a dozen or so of which appeared even remotely related to my classroom needs. And of this dozen, most were math programs, rather than the expected representation of all basic skills areas; I lacked sufficient information to evaluate their appropriateness with my students; and in any case, most were more expensive than my meager classroom budget would allow.

Yet I was convinced that the computer still could be a useful instructional tool with my mildly handicapped students (whose handicaps include learning disabilities, mild mental retardation, emotional disturbance, and orthopedia impairment). These students need well-sequenced instruction, abundant practice of skills and concepts, and immediate, precise correction of errors in order to learn. All of these, I believed, were within the capabilities of computer assisted instruction (herein referred to as CAI), even if programs are not now readily available. More important, perhaps, was my conviction that the computer, like the calculator, would eventually become standard household and office equipment. My students, I felt, need to be exposed now to computers and their uses so that as adults they will be able to employ them as tools, without fear or intimidation.

It was therefore a combination of my ignorance about computers and CAI on the one hand and my faith in their potential on the other that led me to apply for a NWREL study award. In my naivete I proposed what I thought was a reasonable short-term project: identification of other users, evaluation of existing CAI, identification of gaps in existing CAI, and development of programs to fill the gaps. As a grateful aware recipient, I arrived at the Lab some months later with a little more experience and knowledge, enough to realize the enormity of the project and its impossibility within a four-week period. With the assistance of Judy Edwards Allen and Don Holznagle, to whose unit I was assigned, I narrowed the scope considerably. The fourth goal, program development, was eliminated completely. The other objectives were incorporated into one general goal: determining the "state-of-the-art" of microcomputers and the mildly handicapped. As a result of my reviews of the available literature, the topic that later emerged in my mind and which I approached as such in the report that follows became "computers and the handicapped."

The report reflects my discoveries and conclusions. First, much has been done in the area of computers and the handicapped in terms of special education administration, hardware adaptations, and software development. Second, little of this is now commercially available. Third, most existing CAI, developed for other populations (the so-called "normal" students and remedial students) must be adapted and modified before it can be successfully used with the handicapped. Fourth, criteria for evaluating CAI for use with the mildly handicapped (to return in part to the original study proposal) must reflect the special learning needs of this population.

Before going into the major report, though, my activities during the four-week stay, July 27-August 21, should be described briefly. On the first day I met initially with Dr. Rex Hagans, who discussed the study award program and graciously located an office for me. His assistant, Merry Millage, provided valuable assistance in obtaining supplies and materials, and answering questions about the Lab, as she continued to do throughout my stay. I also met with Judy Edwards Allen, who showed me the Microcomputer room and introduced me to the Information Center staff. Later in the day I discussed my project with Judy and Don and by the end of the day had completed the initial steps of an ERIC search with Donna Shaver. Later in that first week I spoke more extensively with Don about the MicroSIFT Project, what it had accomplished and new directions it will take. Don continued to be extremely helpful in assisting my explorations of resources and providing feedback about my project.

My first two weeks were spent largely in the Information Center which contains vast resources in computer technology. The extensive article files, journal collection, and ERIC microfiche files enabled me to have access to information I could not obtain in my own area. I also was able during this period to review some of the journals housed in the Microcomputer unit. Much of the information I obtained is described in the report that follows, but a small portion is incorporated into a separate collection about CAI programs, vendors and resources, a pragmatic activity which will enable me to more knowledgeably purchase CAI materials this year and to establish connections with other users. An additional benefit of my NWREL experience is that these materials will be shared with Lee Trippett, CAI specialist, and other teachers interested in CAI in the Jackson County ESD, my employer.

The third week was spent in reviewing some of the CAI programs available in the Microcomputer room. I agreed to evaluate them for their appropriateness for special education, using the evaluation form and guidelines produced by MicroSIFT. I screened many programs from a variety of producers and documented the evaluation of four programs more extensively. The completed evaluations have been given to Don Holznagle. During the third week I also made contact with a few of the people around the country who are in contact with the Microcomputer Technology unit here at NWREL. One of these contacts, Doug Archer, Special Education Media Specialist in Creston, Iowa, promises to be particularly useful in the future for information and current developments in the field.

My final week at the Lab has been spent in organizing my information into a form that is useful to the Lab. My contribution is the "state-of-the-art" report, the accompanying bibliography and the ERIC searches which yielded over 210 citations on computers and the handicapped. For my own part, I have expanded my knowledge of what can be done for the handicapped with computers, determined what I need to do in order for my students to profit from their experience with the Apple Microcomputer, and established a resource information file to be shared with my colleagues. Clearly the dismay I felt last spring has been dissipated, and I am grateful to NWREL for the opportunity to expand my knowledge and to contribute what I have learned to others.

COMPUTER APPLICATIONS IN SPECIAL EDUCATION ADMINISTRATION

One of the major applications of computers is in the area of special education administration. Although this is not the focus of the present study, and therefore no special effort was taken to seek out such information, a few projects were identified and worthy of interest.

Computers are being used extensively in data management. The Bronx Special Education Regional Office uses a microcomputer system in two ways: 1) a monthly attendance procedure, and 2) interschool articulation (involving projected space needs, student groupings, special student requests, final placement, and student information records (Martin, 1981). Another project, The MONITOR system developed at Utah State University, was designed to meet four needs: 1) assign and monitor timelines for all educational services to be delivered to individual handicapped students; 2) provide timeline summaries of educational services delivered and those yet to be provided to individual students; 3) provide program-wide information on the school's ability to deliver educational services within established guidelines; and 4) make basic student accounting information, such as student counts, available to program administrators (Whitney and Hofmeister, 1981). (An interesting note of caution, however, is being sounded by Joiner and Vensel, 1981. They warn special educators against the mistakes already made by business and educational institutions involved in the development of management information systems: the breeding of facts and reports at a rate exceeding the user's ability to digest them, and the domination of systems design by "technical experts" with little input from line staff.)

The obvious use of computers in administration involves the development and monitoring of IEPs, one of the most time-consuming, non-instructional activities of the special educator. Columbia Learning Systems, a private firm located in Beaverton, Oregon, generates computerized IEPs based on diagnostic information obtained by psychologists. With computer assistance they identify specific student needs from student profiles, cross-reference skill deficits to appropriate strategies and materials for remediation, and monitor student progress toward goals established on the IEP. Similarly, a computerized support system for IEPs known as ORBIT (Organized Resource Bank of IEP Text) is being developed by the Montgomery, Maryland County Public Schools and is described in detail by Koehler, Ossler and Raucher (1981). A system that has been available for some time from Microcomputer Education Application Network (MEAN) is PIE (Programming for Individualized Education) which stores individual student data, analyzes test data, monitors procedural guidelines, and processes information on groups of children.

An application of computers closely related to IEP development, just beginning to be explored, involves diagnostic remedial procedures. While many CAI programs already make use of branching techniques, moving students through material at a faster pace or recycling them through lower skill levels based on performance information, and while several diagnostic programs determine the skills a student possesses or lacks, none that I am aware of actually analyzes what errors the student is making and why, and then provides specific corrections aimed at instructing the student in the correct response. And yet error analysis and fine-tuned remediation is a major task demanded of the skilled special educator and is certainly within the scope of computerized instructional aids. A step towards the development of a computerized diagnostic model is described by Brown and Burton (1977) in the area of basic mathematics skills, based on identification and description of students' knowledge of rules and their misconceptions. At the time of their report the capabilities of the system were solely diagnostic--no tutoring was attempted. The Bronx Special Education Regional Office is investigating with SRA math skills diagnosis and prescription; it will be interesting to see what comes of their venture in the future and the extent to which error analysis procedures are utilized.

Another non-CAI use, developed at UCLA in a non-categorical program for the handicapped, employed the computer in scheduling students into individualized instructional groups. The handicapped children (variously identified as retarded, autistic, seriously emotionally disturbed, learning disabled, or aphasic) in the early childhood program were assigned to instructional groups based on student and teacher variables. Factors such as instructional needs, current level of functioning, classroom behavior, availability of staff members, and space were considered. Although the feasibility of computer-generated schedules for public school settings is yet to be determined, it appears to have the potential for relieving the special education teacher of a very complex, cumbersome task; scheduling (Frankel, et al., 1979).

HARDWARE ADAPTATIONS

Many of the projects involving instructional applications of computers with handicapped students have required modifications of and additions to the basic computer equipment in order to allow the handicapped users to take advantage of the computer's capabilities. Although some of the projects were undertaken with specific handicapping conditions in mind (the hearing impaired, for example, are the beneficiaries of much of the research), the technological advancements have applications beyond the original target population. Therefore, the following annotated list of hardware adaptations is only loosely organized by category of exceptionality, and should not imply that the specified handicap is the only population that can benefit from the adaptation.

Physically/Orthopedically Impaired

- "Joy sticks" can be used to control the interface with a computer, eliminating the need for a keyboard (Jung, 1980)
- Oversized touch sensitive keyboards, measuring 15"x18" with keys measuring 1" square and 1" of space between keys, reduce demands for fine motor coordination (Jung, 1980)
- Passing identification cards through a reader can minimize the amount of information which needs to be correctly encoded (Seyfried and Lowe, 1980)
- Touch panels, well separated, can be used to input simple binary information (yes/no; true/false) (Seyfried and Lowe, 1980)
- Kneeswitches can be used to control the interface with the computer (Jung 1980)
- Hand, foot and head control switches, under pneumatic control also control input (Winters 1978)
- Voice recognition systems, trained to recognize a certain set of words by a particular person, allow students to respond orally to CAI programs (Moursund, 1980-81)
- Audio peripherals that permit the computer to synthesize speech can be used for communication by non-verbal students (Joiner, Sedlak, Silverstein, and Vensel, 1980)
- Computers can be a source of employment for physically handicapped adults who are trained in computer programming (Wieck, 1980)

Visually Impaired

- The Optacon translates regular text into tactile images, one letter at a time (Wieck, 1980)
- The Kurzweil Reading Machine reads text with a synthetic computer voice and can spell out loud any unrecognized word (Wieck, 1980)
- Voice synthesizers provide output in non-visual form (Seyfried and Lowe, 1980)

Hearing Impaired

- Videodiscs interfaced with microcomputers can provide interactive instruction and incorporate still or motion pictures (Nugent, 1980)

- Videotapes interfaced with microcomputers likewise can provide access to wider graphics and animated sequences to illustrate linguistic principles (Withrow, 1979)

Mentally Retarded

- Videodiscs, interfaced with microcomputers, with random access audio provides verbal instruction to non-readers and allow fast transitions to remediation material (Thorkildson, Bickel, and Williams, 1979)

- Touch switches or photo cells employed as input systems allow the most minute student movements to be detected (Seyfried and Love, 1980)

- Metal overlay keyboards containing a small number of keys simplify the computer terminal (Knutson and Prochnow, 1970)

- Special purpose keyboards with keys that illustrate the concepts being taught are used in survival skills instruction such as money, laundry symbols, time, nutrition, cafeteria cashiers, and Bliss symbols (Hallworth and Brebner, 1980)

- Computers interfaced with random access slide projectors, audio cassetts and synthetic speed synthesizers can be used to illustrate in multi-media fashion real life situations (Hallworth and Brebner, 1980)

Learning Disabled

- Light pens allow students to make pointing responses to multiple choice questions or to trace figures (Joiner, Sedlak, Silverstein, and Vensel, 1980)

- Audio output devices, which provide verbal instruction, combined with touch panels or touch sensitive screens minimize the demands on non-readers (Moursund, 1980-81)

- Computers interfaced with random access slide projectors develop language concepts with non or poor readers (Macleod and Overheu, 1977)

- A "button box" arranged in 8"x8" array is used to teach hand-eye coordination, sequential memory and sight word recognition (Macleod and Overheu, 1977)

- A dox-matrix discharge panel, associated with a pen with a pressure-activated switch, is used to teach handwritting skills (Macleod and Overheu, 1977)

SOFTWARE APPLICATIONS

A surprising amount of research has been undertaken, usually in university settings but occasionally within public school systems, to develop courseware or to adapt existing programs to meet the instructional needs of handicapped learners. Unfortunately, little of this is now commercially available. What follows is a brief description of some of the many projects that have been going on. Again, some were designed for specific handicapping conditions but have wider applicability; therefore, the listings are organized by content area.

Mathematics

- The Add Program presents addition problems with sums to 99 in three formats: 2-choice answer, 3-choice answer, and open-ended (Vitello and Bruce, 1977)
- The Shape Program teaches discriminations between geometric shapes and non-geometric shapes and big and little shapes. Four shapes are introduced; circle, triangle, square and rectangle (Vitello and Bruce, 1977)
- The Word Problem Program teaches the translation of word problems into number sequences, requiring the student to specify the operations and operands necessary to solve the problems (Roman and Laudato, 1974)
- Leonard (1970) describes an elementary mathematics principles and operations program for younger handicapped students that teaches numbers and how to use them in performing basic addition and subtraction operations in a series of carefully structured problems
- Sandals (1979) reports on a University of Manitoba project to develop courseware in mathematics for a wide variety (in age and disability) of handicapped students based on a detailed hierarchy of mathematics skills
- Wieck (1980) reports on a Washington, D.C. project to use the math portion of the PLATO Basic Skills curriculum with moderately retarded children
- Suppes and his colleagues have long been involved in the development of a drill and practice mathematics curriculum for deaf children (Suppes, Fletcher, Zanotti, Lorton and Seatle, 1973)

Reading

- Elfner (1973) describes a 3-year project in Florida that developed a reading curriculum for EMR students, of which the computer was only one instructional tool. Much of the project was devoted to breaking down lessons into sufficiently small steps and refining feedback procedures

- Edinburgh University has developed a computer-based system for teaching handicapped children word attack skills by phonics approach. They employ a computer-controlled slide projector and touch sensitive screen in the instruction (Howe, 1981)

- The CARIS (Computer Animated Reading Instruction System) introduces reading to handicapped children by animating nouns and verbs selected by the student. A light sensitive screen is used to teach the vocabulary skills (Geoffrion and Bergeron, 1977)

- A learning disabled child was taught the Dolch sight word list of 220 words on a small home computer. Graphic cues (arrows) were used to establish left-to-right progression of decoding and an audio cassette was used to ensure correct identification of words (Pollard, 1979)

- The "button box" described earlier was used at the Australian National University to develop sight recognition of a basic word vocabulary, including safety words such as DANGER. A sequence of practice activities is used to develop the reading skills (Macleod and Overheu, 1977)

- Leonard (1970) describes an elementary reading program that teaches letter sounds, syllable sounds and spelling of words and syllables. The program employs a computer-controlled random access tape recorder, a slide projector and typewriter

- Wieck (1980) reports that the PLATO program in reading and language arts was used to reach word attack skills, encoding, decoding and comprehension to learning disabled junior high students

Language Arts

- "Building Blocks for Developing Basic Language," a curriculum developed for deaf multi-handicapped children, was translated into an interactive computer program. It is designed to teach vocabulary, categorization skills, sentence structures, and question forms, and it incorporates object drawings and graphic displays of manual communication signs (Galbraith, 1978)

- Moursund (1980-81) reports that touch panels and audio output devices can be used together to develop language arts skills of learning disabled children. The computer displays an image of a chair and a table and signals the audio device to give the direction "Touch the chair," for example

- Microcomputer/videodiscs combine three-dimensional animated sequences illustrating specific linguistic principles with appropriate English language constructions. Hearing impaired students interact with the program to create sentences, and the action is then displayed on the screen (Withrow, 1979)

- Handwriting skills have been taught to learning disabled children using the Australian National University program that employs a Digivue display screen and associated pen, described above. Exercises can be completed only by executing the required sequence of strokes in the specified order and direction and within a preset accuracy level (Macleod and Proctor, 1979)

- Retarded children were taught vocabulary skills, beginning with pronouns, simple conjunctions and verbs, through a program described by Nelson (1972). An introductory sequence first teaches the child to enter his name, correctly spelled, when requested by the computer

- Erting and Mackall (1981) describe the use of PLATO to develop academic skills and appropriate classroom behavior among disruptive hearing impaired students. The children created sentences using vocabulary words presented in instructional lessons, based on a given animation

- Joiner, Sedlak, Silverstein, and Vensel (1980) refer to a recently developed reading and language arts program for secondary students with learning disabilities. The project, completed by Control Data Corporation and Minnesota State Department of Education, is designed around the PLATO timesharing system and is said to be "the most sophisticated instructional system now available for the handicapped"

- Wieck (1980) reports on the teaching of English as a second language through drill and practice to hearing impaired students at Gallaudet College and the Learning Center for Deaf Children in Massachusetts. Writing skills are stimulated with the "electronic mail" technqiues at the Massachusetts program

- Wieck (1980) also reports on the efforts of the National Technical Institute for the Deaf at Rochester, New York to expand the language arts skills of the deaf. They have developed a computer program that diagnoses student writing performance and a tutorial program to improve syntax in writing

- The University of Manitoba has also developed CAI based on their hierarchy of language arts skills. Special needs students work on such skills as phonic analysis, structural analysis, comprehension, vocabulary, word forms and usage, syntax, punctuation, and spelling (Sandals, 1979)

- Basic concepts such as above, below, right and left are tested by a computer-controlled slide projector incorporated with a touch panel. This application, developed at the Australian National University, is based on the Boehm Test of Basic Concepts (Macleod and Overheu, 1977)

- Leonard (1970) describes a spelling program based on the recognition of basic sight words. A slide projector displays pictures of the common words, and the student goes through a series of steps in which he types the correct spelling for each word. A word-guessing program on the order of Hangman has been developed in conjunction with the spelling program and is used to reinforce vocabulary, spelling and working on the spelling program.

- Leonard (1970) also describes the use of the Poughkeepsie Day School Spelling Program with special education students. It is a nongraded spelling program developed on the basis of an analysis of spelling errors made by students in grades 2-9

Survival Skills

- Knutson and Prochnow (1970) developed one of the earliest programs for the mentally retarded that employed a modified keyboard (described above). A metal overlay keyboard with ten oversize keys and removable caps was used to teach money skills. Actual coins were placed on the keys, and the students were instructed to "press the coin" worth a specified amount

- Hallworth and Brebner (1980) describe expansions of the keyboard adaptations. The University of Calgary project has modified equipment to be used in the teaching of money handling, shopping, making change, keeping bank accounts, budgeting, recognition of shapes and letters, social sight vocabulary, nutrition, time sense, laundry symbols, filling in of forms, and training cafeteria cashiers. The materials avoid using content taken from elementary school texts designed to meet the interests of children; instead they are designed to be appropriate for an adult population

- Winters (1978) refers to other applications made by Hallworth and Brebner. Social skills such as how to apply for a job, how to dress appropriately, how to use a calendar and to tell time are also being taught

Miscellaneous

- Learning disabled students have been taught computer programming, problem solving and mathematical thinking through the use of LOGO, a computer language for elementary school students. They control a robot "turtle" that can move and draw pictures on the computer monitor (Weir and Watt, 1980-81)

- The Australian National University has used the "button box" described earlier to teach hand-eye coordination. Students chase a lighted button around the 8"x8" array, and the test can be specialized to require use of either hand(s) or eye(s) in various combinations. It is claimed that the program has also been effective in concentrating the attention of distractable students. Another application of the button box is in developing memory for simple spatial and linear sequences; a pre-determined number of lights turn on then off in sequence, and the student tries to reproduce the sequence (Macleod and Overheu, 1977)

- Not an instructional program in itself but nonetheless designed for hyperactive children is the technique described by Kleiman, Humphrey and Lindsay (1981). Special messages were incorporated into a math program and appeared whenever a child answered too quickly, took too long to respond, or made too many inappropriate button presses (e.g., "STOP IT!")

- The microcomputer/videodisc system for the moderately mentally retarded described earlier (Thorkildson, Bickel and Williams, 1979) was developed based on the instructional package "Matching Sizes, Shapes and Colors." In its CAI form, this matching program was designed to assign student responses to categories including not only correct or incorrect, but also marginally correct. Feedback appropriate to one of the three response types was then given to the student.

- Not an instructional program but rather a software adaptation that makes CAI accessible to the mildly visually impaired is the incorporation of high resolution graphics and the use of highly readable and visible color contrast (Seyfried and Lowe, 1980)

- Leonard (1970) reports on the development of four computerized games for the learning disabled. The games put the student in the role as a participant in a simulated situation and let him solve problems; he is expected to learn by discovery the relationship between variables in the simulated environment

- Leonard (1970) also describes the application of computers to the area of vocational skills for special education students. One program gives students experience in completing job applications and several others are being used in exploratory vocational activities, providing simulations in such areas as automotive and television repair

TEACHER AIDS

Several projects have been started to assist the special educator in utilizing computers in the classroom. As Berthold and Sachs (1974) state succinctly, "Most special education teachers lack the time or motivation to acquire complicated programming skills, and the possibility of supplying teachers with trained programmers who are constantly available to adapt lessons to individual students' needs is economically difficult" (pp. 121-122).

- Berthold and Sachs (1974) refer to a simplified programming language termed MR. COMPUTER which teachers without previous programming skills can master in a few hours. It incorporates many techniques designed for preparing and adapting individual lessons

- Thorkildson, Bickel and Williams (1979) programmed their Apple Microcomputer which interfaces with a videodisc in PILOT, a computer language for Apples that is specially designed for CAI. They designed the microcomputer/videodisc system so that teachers can ultimately develop their own CAI courses or instructional models.

- ASSIST (Authoring System Supplementing Instruction Selected by Teachers) is a CAI system developed by RMC Research Corporation. Its aim is to demonstrate and evaluate computer programs for mentally handicapped children; another goal is to allow teachers to create and assign CAI lessons in any curriculum area for any student population. Ten different models of lesson presentation formats such as multiple choice format, copy format and binary format (yes/no; true/false, etc.) have been programmed; teachers merely submit their content information and specify special corrections (Chiang, 1978)

- An aid of a different sort has been developed at the Special Education Instructional Materials Center, State University College at Buffalo. They have used the computer to assist in the pre-planning process of using resource units. Existing units were evaluated for appropriateness with special education students, and new units were developed to meet additional needs of exceptional children. The information about materials, objectives and units was then stored on computer (Leonard, 1970)

- A project currently going on in Creston, Iowa is the collection, evaluation and cataloging of CAI for the handicapped. It is planned that the final product will catalogue programs alphabetically, by content area, grade level and company (Archer, 1981)

AVAILABLE CAI AND THE MILDLY HANDICAPPED

Despite the demonstrated range of applications of computer technology to the education of the handicapped, commercial software producers have generally not targeted this potential market. In my preliminary reviews of the most popular software catalogues, I found only one CAI product specifically identified as being for the handicapped: MECC Special Needs, Volume I, Spelling, available July 1981. In personal conversation with Doug Archer, Special Education Media Specialist in Creston, Iowa, I found that there is a small number of other products. Interpretive Education has developed a series on basic living skills for secondary TMR students, and Grover Associates has a package called Microcommunicator which is designed for non-communicative students. Most of the materials he has identified for special education students, however, come from schools and are not available from commercial producers. MECC System Library contains a catalogue of programs which can be used with students with special learning or behavioral problems, though not written specifically for this population. Not a CAI instructional material alone, but nonetheless developed for handicapped secondary students, is Microcomputer Education Applications Network's SP ED READ. This is a testing and functional reading drill program which also includes listing of objectives and curriculum materials references. As noted before, Martin (1981) states that the Bronx Special Education Regional Office in conjunction with SRA is investigating mathematics skills diagnosis and prescription for special education students involving programs already developed by SRA, so presumably additional software products for this population will be available from commercial publishers at some point in the future.

Nonetheless, at the present time commercial software for handicapped students is extremely limited. Jostad and Kosel (1980) reviewed educational software from 35 companies and found that the distribution for elementary schools by subject area (total sample: 700 programs) was lowest for art, science and special education. These three subject areas were not even reflected on the graph whose scale was in units of 5 instructional programs. One might surmise that special education's neglect is partly due to its small population of students. Another factor may be that software developers are concentrating on software which is the easiest to produce, drill and practice (Jostad and Kostel, 1980), thus avoiding more complex programming requirements which software for the handicapped presumably demands. Certainly the projects for the deaf, blind, physically impaired, and moderately/severely retarded referred to above involve sophisticated software or hardware modifications, and in any case most are still in the development stage, not yet commercially available. Yet the mildly handicapped (i.e., learning disabled, mildly mentally retarded, and emotionally disturbed) in most cases do not require the complex technological modifications of the more severely impaired students. In fact, the educational needs of the mildly handicapped are strikingly similar to those of the student population in general: instruction and practice of the basic skills--reading, spelling, language arts and math. Because so many excellent CAI programs already exist in these content areas, the question is whether or not the existing CAI can be used with low performing students.

Undoubtedly some courseware can be used with mildly handicapped students without modification. But, in fact, many special educators have had to adapt available software to the needs of their students. The following is a list of some of the presenting problems in the software as is and some of the adaptations that have been made in response.

- Readability is the factor which most interferes with successful, independent use of computers by the handicapped. Students who have not attained the reading level demanded by the printed text will make errors not necessarily because they fail to understand the concept or skill involved but because they misinterpret the text. Seyfried and Lowe (1980) cite the use of speech synthesizers to permit oral presentation of material along with visual. Thorkildson, Bickel and Williams (1979) refer to random access audio in their discussion of using microcomputer/videodisc systems with the non-reading, moderately mentally retarded, an adaptation which would work with any non-reader, regardless of handicapping condition. Leonard (1970) documents the technique of changing the vocabulary of printed messages to make the reading level appropriate to the target population. Audio output devices are suggested by Knutson and Pruchnow (1970), Moursund (1980-81), and Joiner, Sedlak, Silverstein and Vensel (1980)

- A related difficulty is the inability to understand and follow directions independently. Complex, length instructions can, of course, trouble normal students as well (and are often a programming problem rather than a student problem), but even clear, simple directions can overload a handicapped student, even one capable of decoding the words. Nugent (1980) mentions additional prompting as one solution. Obviously clean, well thought out programming with special care given to visual displays and concise directions will reduce the burden on the mildly handicapped

- Corrective feedback, while important for normal students, is essential for special education students, if guessing strategies and practice of errors (not to mention frustration) are to be avoided. Leonard (1970) suggests providing more hints that lead to the correct answer and providing the correct answer sooner (rather than "WRONG--TRY AGAIN") on questions of a factual nature. Frequent, non-threatening and non-demeaning feedback (positive and corrective) is, of course, a prerequisite (Chiang 1978)

- Response time is often slower for the handicapped, whether because of the nature of the handicap itself or because of an associated difficulty in reading, computation or other academic skill. Leonard (1970) advises lengthening the allowable response time while Elfner (1973) found that removing time constraints altogether was most effective

- The load on short term memory must be minimized because many handicapped students have a deficiency in short term memory. Hallworth and Brebner (1980) recommend immediate feedback so the student does not lose track of the problem, and providing cues such as counting devices. Breaking instruction into short segments and demanding frequent student responses should also help

- Criteria for mastery sometimes are inappropriate for the handicapped, particularly the mentally handicapped. Leonard (1970) states that criteria were often too stringent which frustrated students because of their inability to proceed to more complex problems. He found that success was achieved by decreasing the percentage correct needed to advance to a higher skill. Note, however, that many special educators would disagree with this perspective, arguing that overlearning of material with more, not less, stringent criteria and extra repetition are needed to ensure mastery (Chiang, 1978). In any case, varying criteria levels (up or down) appears to be an adaptation of available CAI, one that is not applicable to handicapped students alone but normal students as well

- Small steps in learning are essential for most students with learning problems, and many commercial materials require cognitive leaps that are too great to be bridged by special education students (and probably by many non-handicapped as well). Elfner (1973) found it necessary to create new levels of material within the structure of the original CAI materials. Supplementary materials such as slides and recorded tapes were made available by Leonard (1970) to enable special education students to use computerized economics games. Additionally, when skills become too complex for the handicapped student's current level of functioning, they can be eliminated from the student's CAI activities

- Perception and attention to relevant stimuli is a deficiency of some handicapped students, particularly the retarded. Hallworth and Brebner (1980) suggest that in early stages of learning only the critical information or stimuli be presented; gradually and systematically other information will be added, with careful thought being given to teaching discriminations between relevant and irrelevant information, examples and nonexamples, and alternative forms and formats

- Keyboard terminals can be particularly difficult for the handicapped, not only for physically impaired whose fine motor skills are poor, but for physically intact individuals whose typing skills make responses of more than 1-2 characters laborious and frustrating. (Of course, this can be true of normal students as well.) Moursund (1980-81) recommends teaching touch typing skills as one solution. Many programs assume that students can type their names; some handicapped students (usually those who are either younger or more severely involved) may lack this preskill. As noted before, Nelson (1972) refers to an introductory sequence which teaches the student how to enter his name when requested by the computer. Seyfried and Lowe (1980) suggest that passing an identification card through a reader can eliminate much of the typing demand in sign-in procedures. An obvious adaptation, useful for all students, handicapped and non-handicapped, is to limit the response mode to single character responses (Y/N; T/F, etc.) when possible or to employ light pens or touch panels

- Matching learner characteristics is another problem which is not exclusive to the handicapped. For the learning disabled, though, who are often frustrated learners, having to use materials which are appropriate for current skill levels but not to age or interest levels, is an added irritant and impediment to learning. Leonard (1970) notes the obvious: selecting CAI materials, as any other instructional material, involves not only appropriate content and objectives, but also information of concern to chronological age, to interests and understandable to mental age. This applies not only to content material, examples and illustrations, but to sound and graphics as well; a high school age handicapped student who needs to practice addition skills may not appreciate a happy face being flashed on the screen after every problem .

EVALUATION OF CAI FOR THE HANDICAPPED

It should be apparent that the problems with currently available software and most of the solutions suggested in the literature are by no means unique to the mildly handicapped. This merely reinforces the notion that mildly handicapped learners are more like the so-called "normal" students than different. However, whereas a normal student can utilise and learn from most carefully selected CAI programs without modification (however less efficient and effective the learning might be), this is probably less the case with handicapped students; without thorough evaluation and adaptation, where necessary, of commercial courseware, special education students stand to profit little from the time spent at the computer terminal. Unfortunately, the documentation of software which is needed to evaluate, adapt and modify programs is a low priority item by developers. This is demonstrated in Jostad and Kosel's (1980) evaluation of 29 sample vendor programs: on a scale of 9 (low) to 5 (high), tutorial strategy programs were rated 1,75 on documentation; drill and practice, 2.10; educational games, 2,50; problem solving. 4.25; and simulation, 4.25. Thus the programs most likely to be used by handicapped students (tutorial, drill and practice) have the least documentation which would facilitate evaluation and adaptation for these students.

In view of the less than adequate documentation and the need in many cases for modification of existing materials, good evaluation criteria, specifically addressing the educational needs of the mildly handicapped, are necessary. Vitello and Bruce (1977) have identified 3 attributes of CAI which are particularly relevant to the characteristics of the handicapped: 1) the use of multi-sensory presentations of materials which eliminate or reduce the requirement of reading for the poor or non-reader; 2) the repetition of material which insures sufficient practice and over-learning for the slow learner; and 3) the immediate remediation of incorrect responses which presents further failure. Based on the already documented problems in using existing CAI programs with the handicapped, Vitello and Bruce's observations (above), and on pedagogical standards for instructing the mildly handicapped described by Archer and Edgar (1976), what follows is a set of considerations that requires particular scrutiny as courseware is reviewed for use with special education students. Where applicable these guidelines are corss-referenced to items listed in the Evaluator's Guide developed by MicroSIFT.

GENERAL CONSIDERATIONS IN SELECTED CAI

Entry Skills

- Are the entry behaviors demanded by the program easy to ascertain? (15b)
- Does the program provide a method to determine initial placement in the material? (12d)
- Are the students capable of making the responses required by the program (i.e., using the keyboard and other accessories)? (7a)
- Do students have the reading skills required by the program? (7b)

Content

- Does the program present the major concepts that you wish to stress? (2e)
- Are the concepts presented clearly? (6a, 6e)
- Is adequate practice of the skill provided?
- Is adequate repetition of concepts provided?
- Does the material match the chronological age and interests of the student? (7c)
- Is the skill or concept best presented by computer as opposed to other modes of presentation? (20a)

Assessment of Student Mastery

- Is student performance assessed at intervals throughout the program? (7f, 11h)
- Is student performance data used to make decisions about movement to higher or lower skill levels? (7f)
- Are mastery criteria adequate and appropriate?
- Is feedback on student performance provided to teachers? (19e)

CONSIDERATIONS IN SELECTING DRILL AND PRACTICE CAI

Practice Activities

- Do activities focus on skills at the level of proficiency or maintenance?
- Do practice activities closely match the task that is ultimately to be performed by the student in the natural environment? (14b)
- Is there an adequate number of practice activities?

Independence of Task Completion

- Can students complete the program with minimal supervision?
- Are directions simple? (7b, 17c)
- Does the program include only a limited variety of student tasks?
- Are student responses standard and easily recognizable? (18b)
- Does the program ensure that students know the exact demands of the task? (18h)
- Are prompts or hints used when needed? (11d)
- Is feedback on performance provided to students? (11e)
- Is student performance data provided to teachers? (19e)

CONSIDERATIONS IN SELECTING TUTORIAL CAI

Sequence

- Is the sequence written in terms of student behavior? (4c)
- Does the sequence move from least complex to most complex? (7f)
- Does the sequence move from most frequent elements to least frequent?
- Does the sequence include all intermediary behaviors that lead to the terminal objective?
- Does the sequence avoid large jumps that would cause difficulty for handicapped learners? (7c)
- Does the sequence include a sufficient breakdown of steps? (7e)
- Does the sequence note entry skills? (15b)

Instructional Strategy

- Does the program focus on skills at the level of initial acquisition?
- Are skills and concepts introduced systematically?
- Is information presented in a logical, organized manner? (6a, 6e)
- Does the program provide instructional input on how to perform the skill? (6c)
- Does the program demonstrate the desired response to the student? (6g, 11f)
- Is vocabulary consistent and simple? (7b)
- Are students actively included in instruction? (10a)

Practice of Skills

- Is there an adequate number of practice activities?
- Are prompts and hints provided when needed? (11d)
- Is the use of prompts and hints faded out when no longer needed?
- Is feedback on performance provided to students? (11b, 11d, 11f)

Sequence

- Is the sequence evident in the material? (6e)
- Does the sequence proceed from simple to complex? (7f)
- Does the material proceed in a logical order? (6e)
- Are the steps in the sequence small? (7e)

Objectives

- Are the objectives stated for the material? (4a)
- Are the objectives similar to your objectives?

Ongoing Assessment

- Does the program assess student performance? (7f, 11h)
- Does the program make provisions for reporting student performance to the teacher? (20b)
- Is performance data as reported by the program compatible with classroom data collection procedures?

Feedback

- Does the material provide positive and corrective feedback to students? (11)
- Do correction procedures specify how to alter incorrect answers? (11d)
- Are students provided with performance feedback on progress toward goals? (11e)
- Is feedback provided frequently? (11c)
- Are reinforcers appropriate to the responses demanded (neither too big nor too small)? (11a)
- Are reinforcers contingent on the desired students' behavior? (11a)
- Is corrective feedback balanced with positive interactions for correct performance?
- Can the program analyze student error responses to provide specific remediation?
- Can the program alert the teacher to specific error patterns?

- Is feedback for correct performance more desirable than feedback for incorrect performance, so that the student is not encouraged to make deliberate errors?
- Is the number of allowable responses per question limited so that the student is not encouraged to guess?
- Are traps used to detect and correct potential errors of any kind? (18g)

Adaptability to Individualization

- Can students use the materials independently, with minimal supervision? (19f)
- Can students be placed into the material at their own levels? (12d)
- Can students advance to subsequent tasks when they have demonstrated proficiency? (7f)
- Can students progress independently? (7f)
- Can the criteria for movement to higher or lower skill levels be varied?
- Does the program encourage active student participation? (10a)

Generalization

- Is the task performed by students similar to tasks required in other instructional settings? (14c)
- Are provisions made to assist students in transferring skills to the natural setting?
- Will the skill be useful to students outside of the instructional settings? (14a)

Physical Characteristics

- Do text and graphics enhance rather than detract from student learning? (8a)
- Does the program avoid graphics which distract students from the instructional purpose at hand? (17o)
- Do graphics serve an instructional purpose (i.e., not used for entertainment alone)?

- Are type size and graphics suitable to the maturity of students? (7c, 17g)
- Are graphics simple, with adequate spacing? (17a)
- Does the program avoid lengthy, crowded text? (17d)
- Does the time required to use the program match students' attention spans? (7d)
- Can students control the time allowed for solving problems? (12a)
- Can students control the rate of peresentation of text and graphics to suit their own reading rates? (12b)

Information to Teacher

- Is essential background information provided? (15b)
- Is the sequence of the material specified? (6e)
- Are the instructions to the teacher clear and complete?
- Are sample runs included? (15c)
- Are sections of the program easily located?
- Can the program be supervised without sophisticated programming skills? (19a)
- Can the program be modified to suit individual student needs? (15c)
- Is information to the teacher about student performance sufficiently detailed? (19e)

Aside from these general considerations, specific thought must be given to the purpose for which the CAI programs will be used with students. The two major uses, tutorial strategies employed during the initial acquisition stage and drill and practice strategies for the proficiency and maintenance stage, involve evaluation criteria with slightly different emphasis. These criteria are listed below, restating the general considerations in a different format, with additions and deletions made as appropriate.

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APPLICATIONS OF TECHNOLOGY TO THE TEACHING OF BASIC SKILLS

Prepared by

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THE STATE OF THE ART IN INSTRUCTIONAL TECHNOLOGY

INSTRUCTIONAL DESIGN

Instructional technology is generally accepted to include not only the hardware and courseware (programs, tapes, written materials, etc.) used in delivery of instruction, but also the process used to develop the courseware--commonly referred to as instructional systems design (ISD). ISD, which incorporates the techniques of objective and item specification, task analysis, and the systems approach to curriculum development is heavily used in the military in the development of training materials, and increasingly used in education. The recent experimental work in "cognitive science" (Atkinson, 1980) adds a new and important dimension, as it synthesizes concepts from artificial intelligence and cognitive learning theory. The availability of interactive electronic media to deliver instruction provides the opportunity and the impetus to incorporate the best of current knowledge about how people learn into our curriculum development practices. The following statement characterizes the challenge to psychologists and behavioral scientists:

> ...research trends in cognitive psychology and instructional systems are shifting from an emphasis on effective methods to acquire facts and skills to the study and development of intelligent, knowledge-based instructional systems. Knowledge-based systems are being developed which so thoroughly "understand" the subject domain and the student's grasp of the subject matter that they are able to assist the student to recognize, articulate, and use diverse forms of information in problem-solving environments. These developments are not simply new wrinkles in educational research, they are assaults upon the basic questions of "What is knowledge?" and "How is it best acquired?" These research efforts are laying the

> foundations for the solution of a much larger set of educationally significant problems than has even been considered in the past (Atkinson, 1978).

The potential benefit of recent research in cognitive science to the remediaton of basic skills deficiencies appears to lie in the area of error analysis. Recent work by Brown (1978) exemplifies an approach to error analysis that goes far beyond the current practice of treating an error in arithmetic, for example, as simply a feedback problem, solved by providing the student with the correct answer. Brown uses the computer to analyze the pattern of student responses, simulate the kinds of errors the student is liable to make from the inferred faulty procedures, devise an automated tutorial system to assist the student when an error is made, and give the student insight into the process of generating errors by challenging him or her to figure out procedural errors programmed into the computer.

Instructional systems design and cognitive science, although they contribute to and are a part of the general field of instructional technolgy, will not be dealt with extensively in this paper, except to provide context and background.

HARDWARE

The hardware of instructional technology can be defined as the electronic media--radio, television, calculators, computers and videodiscs--together with the more mundane film, audio tape, and reading machines. The latter media have not advanced remarkably in recent years, and little empirical evidence can be found as to their effectiveness in teaching or remediating basic skills. The newer electronic media can provide the same capabilities as film, studio, and reading machines, but when combined with computers, are envlivened and made more powerful and flexible. Thus, in this review the electronic media will be described and discussed rather than the older technologies.

Radio

The single important demonstration of radio as an instructional medium is the Nicaragua project described in the literature review. Using radio to teach basic skills in mathematics, the project was a success for that population. The materials were developed in Spanish, and the expense and effort involved were tremendous, as reported in a conversation with Barbara Searle, a principal investigator.

Delivery of radio programming is dependent on access to broadcast transmission and must be scheduled for a particular broadcast time. In the Educational Telecommunications for Alaska (ETA) project, radio was considered as a medium for delivery of instruction in remote bush areas and was discarded for the following reasons:

1. Fewer than half of the geographically isolated target schools were in an area reached by commercial or public broadcast radio.
2. Scheduling of programs for broadcast placed severe limitations on the flexibility of the classroom teacher to use the materials appropriately.
3. The expense of developing and testing the audio scripts was at least equal to that for other media.

An advantage of radio where instruction must be delivered by satellite telecommunications is that it is a "narrow band" technology as opposed to, for example, television, which is a "broad band" technology. That is, radio requires a small fraction of the satellite band width required by television for storage and delivery of signals. Thus the cost is considerably lower to deliver radio instruction via satellite than to deliver television instruction.

Television

Television as an instructional medium has received much attention both negative and positive. With the availability of the educational programs developed by the Children's Television Workshop for commercial TV ("Sesame Street" and "The Electric Company") educational effectiveness could be and was demonstrated. Locally developed programs, off-the-air taping, and purchase of commercially available videotapes add to the scheduling flexibility of the classroom teacher.

"Smart" television, a melding of computers and television, is a creation already being marketed in Britain and France and being tested in Canada and the United States. Predictions are that smart television, generically known as videotext or teletext, will replace ordinary television in the next decade. The systems will allow subscribers to use their own TV set (with a small attachment) to receive almost any piece of information that can be fed into a computer. Videotext two-way communication networks will allow us to create a text or a graphic and have it sent to a computer bank where other viewers can have access to it. People can work together although hundreds of miles apart through the "electronic mail" and "electronic blackboard" features of the system. The experimental QUBE system in operation in Columbus, Ohio is an example of the interactive use of videotext, which focuses primarily on entertainment, through a cable television network. Two other Columbus-based efforts are OCLC, which provides subscribers with information via telephone and television with punch key consoles, and

Compuserve, which provides information on an interactive terminal using a telephone link. Compuserve provides news and weather, electronic mail, money management information, and games between users or between user and computer. Also available is access to the MicroNET software exchange which allows users to purchase programs electronically and have them "downloaded" (sent over telephone line) into their personal computers error free and ready to run.

Calculators

Handheld calculators have declined in cost to the point that they are almost as "disposable" as a ball point pen. A calculator offering the four arithmetic functions, square root, trigonometric and logarithmic functions sells for under $10. Several models have been extended to provide arithmetic drill or games, for under $25, and a spelling drill with "voice feedback (simluated) is available for $50. As the cost of electronic components continues to decline, such devices will also decline in cost.

Computers

In the mid-1960s educators believed that the computer had the potential to become ubiquitous in American education. It was expected that computers would make it possible to realize important changes in the availability and effectiveness of education. In 1975 Bennett Cerf predicted, on CBS, that within five years every school child in the state of Pennsylvania would have a computer terminal built into his or her desk. That state of affairs did not come to pass. In fact, by 1970 even CAI's most ardent protagonist, Patrick Suppes of Stanford, had dismissed

CAI as an approach to mass education because it was economically prohibitive (1970). The studies in computer-assisted instruction were for the most part well-financed experiments whose costs could not be borne by most school districts when the funding ended.

During the period of the mid-60s through the mid-70s one notable large scale sophisticated system was the PLATO project. Begun at the Univesity of Illinois and now a product of Control Data Corporation, PLATO offers sophisticated but expensive courses via terminals linked to a large central computer. The PLATO system has been seen as the Cadillac of CAI, and is still in use. For the most part, however, the dream of using technology to achieve important educational objectives had died by 1975.

That situation began to change when the affordable desk top microcomputer was introduced in 1976. A small portable microcomputer can now be purchased for $2000 which has the same power that before 1970 would have cost nearly $250,000, would have required 100 or so times the space and would have been less reliable. In fact, one can compare the $500 Radio Shack TRS-80 microcomputer to the first digital computer built at Harvard in 1944, the Mark I. The $500 machine, which represents the minimum of what currently available microcomputers can do, compares well to the Mark I. It is 10,000 times as fast, contains 16 times as much memory, and costs 1/250 as much.

A typical and basic microcomputer configuration would include the following components:

1. A microprocessor unit in a typewriter-like case with keyboard. The unit can store and process at least 4000 (4K) characters, and is expandable to 64K or more. Cost of the unit is upward of $500, depending on capacity.

2. Auxiliary storage in the form of cassette tape of 5-inch diskette ("floppy disk"). A diskette drive sells for about $500.

3. A video display. Most microcomputers can be interfaced to a standard television set, color or black and white, for display of input and output. A simple and inexpensive video monitor can also be used.

4. A printer. Small and versatile printers which print graphic displays as well as standard keyboard characters are now available for $500.

The microcomputers currently on the market incorporate additional features and peripheral hardware devices that simply did not exist (or only at great cost) in the technology of the 60s and 70s. A representative list of these new "accessories" would include:

1. Computer-controlled (and programmable) graphics. The more primitive "low resolution" graphics, high resolution graphics, character graphics, and vector graphics offer a selection of sophistication and cost.

2. A "graphics tablet". A peripheral device which allows the user to draw any desired visual, with shading and fine detail, on an electronic tablet which transmits the drawing directly into computer storage for later retrieval and modification or display.

3. Full color displays, with two dozen colors programmable for use in graphics or textual displays.

4. Speech generators. The cost of programmable speech generators or voice synthesizers has decreased dramatically in the last two years, and will continue to decrease from its present cost of $400.

5. Voice recognition devices. These devices start at $300, and can be programmed to recognize a set of spoken words.

6. Music generators. The range is from simple devices that string together single notes to polyphonic generators that can be programmed to control attack, decay, and timbre. A piano-style keyboard is available as a peripheral device for under $2000--music composed and played at the keyboard is stored by the computer and can be manipulated, transposed, and added to, while colored bars representing the musical sounds dance on the display screen.

Videodisc

Beginning next September, 20 hours of television programming will become available on videodisc for middle-grade classrooms. The series, called Schooldisk, is the result of a collaboration between ABC (technical expertise) and NEA (content expertise). The 20 discs will sell at $7.50 to $10 each, and will require the lease or purchase of a $700 playback device. Schooldisk will offer more scheduling flexibility to the classroom teacher than does broadcast television, and has "freeze frame" capability far superior to that of video tape.

This first incursion of videodisc into the clasroom takes advantage of only a few of the characterstics of videodisc technology. A single side of a virtually indestructible disc currenty can store 54,000 separate full-color frames of pictures, alphanumeric or computer information, to deliver 30 minutes of video. Each of the separate frames in numbered and randomly accessible. Any portion of a motion picture can be replayed, backward or forward, at regular or slow speed.

An "intelligent" videodisc, which combines a microcomputer with the videodisc, is not yet commercially available, but is being demonstrated at several experimental sites. Such a system capitalizes on the random accessibility of videodisc frames, allowing the instructional designer to program the display of a particular single image or a motion picture segment in any desired combination, contingent on student response. The videodisc has the capacity of storing large quantities of digital data--about 10 billion bits, or 5 times the information contained in the Encyclopedia Britannica. Thus, CAI programs can themselves be stored on the first few hundred frames of the videodisc and transferred into the microcomputer to begin a CAI lesson.

COURSEWARE

The state of the art in availability of courseware for delivery via electronic media, particularly in the basic skills, is one of burgeoning development and increasing sophistication. Commercially available or public radio programming for remediation in the basic skills is very limited. Television or video tape courseware is available commercially in much the same way as instructional films--virtually anything is available in the general fields such as U.S. history and literature, but very little is yet available to teach specific skills, as in reading or mathematics.

Calculators which drill in mathematics and spelling have the "courseware" built in as part of the hardware.

For CAI courseware, the situation is such that any statement characterizing the state of the art will be outdated and obsolete by the time it is printed. The basic skills CAI curriculum has been dominated by the Computer Curriculum Corporation (CCC) which licenses mathematics, reading and language arts courseware delivered by terminals connected to a minicomputer. Basic skills reading and mathematics materials on the PLATO system are available on terminals connected to a very large time-shared computer, and soon will be available through a diskette drive unit attached to a PLATO terminal.

Beyond these two well-known systems, however, there has been little available that could be called validated basic skills courseware. Microcomputer courseware has proliferated in the last two years through a "cottage industry" of individual entrepreneurs. The resulting state of the art was very well described by R.E. Purser in a disclaimer which he printed on the back of his microcomputer software catalog:

> Well meaning, "instant" programmers are selling amateurish, awkward, or awful programs. They have brilliant ideas but cannot express themselves using a computer. It is like a first-year French student trying to write the great French novel.
>
> In time most of the programs on the market today will be rewritten, improved, and polished. But for now, 95 percent of all the programs listed in this magazine should never have been offered for sale.
>
> Be careful. Be selective.

The situation has changed dramatically in recent months, however, as one major publisher after another has announced plans or products to teach basic skills by microcomputer. Competitive basic skills courseware is or soon will be available from Tandy Corporation (Radio Shack), Scott-Foresman (Texas Instruments), SRA (Atari and Apple) and Random House (Radio Shack). Other publishers have indicated a commitment to major development of microcomputer courseware, with basic skills as the top priority for most publishers.

A REVIEW OF RESEARCH ON THE EFFECTIVENESS OF CAI IN BASIC SKILLS INSTRUCTION

A review was conducted in Fall, 1980, of research on the effectiveness of computer assisted instruction (CAI) as compared to other forms of instruction. CAI is generally characterized by the interaction of a student at a computer terminal with instructional material (a question, a paragraph, a number, etc.) presented by the computer system. The student responds by typing an answer or command and the computer responds with additional instructional stimuli which may be some function of the student's previous response. For purposes of this literature search, CAI includes drill, practice, tutorial, problem solving, and simulation, which are defined as follows:

- drill--student responds quickly to brief items or questions, much like traditional "flash cards";
- practice--student answers more complex questions which may require more extensive interaction with the computer;
- tutorial--textual materials and questions are presented to the student, and frequently uses branching based upon the student's response;
- simulation--models a portion of reality and allows the student to experience the interaction of complex events;
- problem solving--student applies principles and rules to various situations.

Studies included in this report are primarily limited to elementary and secondary education, but basic skills applications of CAI in higher education are also included because of their relevance for younger students who have not arrived at the needed level of competency.

This review of research will present evidence relative to the effectiveness of CAI on student achievement, motivation and attitude toward CAI, retention of material, comparisons of time to learn subject matter, and teacher-student interaction.

Computer-managed instruction (CMI) and the teaching of programming or computer science are not included unless a CAI component is evident. CMI is differentiated from CAI in that the computer is used for tasks such as: diagnosing, assigning, routing the student through the curriculum, progress evaluation of related record keeping.

METHODOLOGY

Relevant literature dealing with effectiveness of CAI was located in several ways. The Educational Resources Information Center (ERIC) data base was searched using a variety of descriptors, and yielded many documents which would otherwise have been unavailable. The Education Index was used to identify relevant material published in the last three years. A search was also made of the Dissertation Abstracts International to locate recent doctoral dissertations which explored aspects of CAI. Other sources such as educational journals were scanned and a telephone survey of key individuals with CAI experience was conducted.

Even though more than 100 studies were examined, usable results of the review were less than anticipated. This was due to several reasons: (1) some potentially valuable research projects are currently underway, but do not yet have any data available; (2) the literature lags behind research by several months; (3) studies done by commercial suppliers of courseware are not included in this report; (4) the largest problem, however, is that many of the studies located were not usable because they did not apply accepted research techniques. Results and claims whose validity could not be verified by data within the study were not included. Many studies indicated positive results from CAI, but did not use other groups of students for comparison. These studies cannot answer questions about the relative efficiency of CAI as compared to other types of instruction. Student achievement data from such studies are not included in this report. Furthermore, the evidence of effectiveness has not been reported unless the likelihood of the results being due to chance is less than one in twenty.

SURVEY RESULTS

STUDENT ACHIEVEMENT IN GENERAL

Several previous literature reviews (Jamison, Suppes, and Wells (1974); Edwards, Norton, Taylor, Weiss, and Van Dusseldorp (1975); and Thomas (1979)) examined studies on the effectiveness of CAI in student achievement.

Edwards et al. (1975) reported that all studies examined showed that normal instruction supplemented with CAI was more effective than normal instruction alone. When CAI was substituted, in whole or in part, for traditional instruction, studies were almost evenly divided as to whether students receiving CAI achieved more or about the same as non-CAI students. When different types of CAI were compared, mixed results were observed between increased achievement and no difference for CAI and non-CAI students. Edwards et al. (1975) also reported that CAI was equally effective when compared to individual tutoring, language laboratory, and various media, such as programming instruction and filmstrips.

Thomas reviewed over thirty studies in a variety of disciplines which were related to the effect of CAI on achievement. Four studies showed approximately equal results for CAI and other modes of instruction; one study showed negative results (a beginning typewriting course). The other sources reported positive results with the use of CAI in basic mathematics, language arts, reading, career information, biology, algebra and physics. Drill, practice, simulation, tutorial, and problem solving types of CAI were all included.

Reading

Jamison et al. (1974) summarized the results of several studies dealing with applications of CAI to the teaching of reading, where it was shown to be an effective supplement to regular instruction. This was especially true with CAI drill and practice for students who start below grade level.

Two studies reported by Jamison et al. (1974) indicated that CAI tutorial programs in first grade beginning reading resulted in comparable scores for boys and girls. This is an important finding since boys, on the average, do not show an initial reading achievement level equivalent to that of girls. Litman (1977) analyzed the results for fourth through sixth grade students, and reported that after one year fourth and fifth grade males receiving CAI drill and practice scored significantly higher than non-CAI males. Anelli (1978), however, found that disadvantaged third and fourth grade girls gained more than boys.

Results of a three-year project for supplementary CAI in selected

Title I schools in the Los Angeles Unified School District were reported by Ragosta, Jamison, Juhnke, Woodson, and Holland (1980). Students were pre-tested at the beginning of fourth grade and post-tested at the end of the sixth grade. The CAI students received three drill and practice applications from Computer Curriculum Corporation (CCC) in different combinations: mathematics, reading and language. A control group of students received no CAI. Students who used all three curricula scored significantly higher gains on the vocabulary subtest of the California Test of Basic Skills (CTBS) than did the control group.

At the end of the sixth grade, the same students were also given tests to measure specific material covered in the fourth, fifth, and sixth grade curricula. Those who worked with CAI mathematics, but neither reading nor language arts, scored significantly lower on one section of the reading test, giving added credence to conclusions that CAI in reading and language arts did have positive effects. Ragosta et al. report that language arts scores, more than reading scores, were improved by using the reading and language arts curricula.

A parochial junior high school CAI project, conducted over a three-year period in an inner city section of New York City was reported by Wilkinson (1979). Students were predominantly black or Hispanic. Those receiving CAI scored significantly higher on the reading portion of the SRA Achievement Test than students in a traditional program.

Similar results were reported by Mravetz (1980) for rural, Caucasian junior high students who were reading at least one year below actual grade level. CAI students scored significantly higher on reading achievement than did comparable students having the same teacher.

Maser, Johnson and Davis (1977) determined that CAI drill and practice in basic skills was an extremely viable method for raising basic skills performance levels when used to supplement good teaching. Two school districts (Highland District, Seattle, Washington and Ft. Worth Independent School District, Texas) used CCC courseware for Title I reading and language arts, and reported gains in excess of one month for each month spent in the program. Participants in the three-year project were Title I students in grades two through nine. Lysiak, Wallace, and Evans (1976) reported that supplementary CAI generally increased vocabulary and reading scores in grades 3-7.

Mathematics

Maser et al. (1977) discovered that the objective of one month's gain for one month's participation for second through ninth grade students was also reached when using a Hewlett-Packard mathematics CAI program. Lysiak et al. (1976) reported mixed results for CCC mathematics materials in grades 3-5, but indicated that middle school CAI students generally achieved more than control group students. Ragosta et al. (1980) reported that students who had received the CCC mathematics curriculum in grades 4-6 scored significantly higher on a curriculum-specific math test than did the control group. Wilkinson (1979) indicated that CAI students scored significantly higher on the SRA Achievement Test in mathematics.

Wells, Whelchel, and Jamison (1974) reported significant gains in mathematics (about one-third year higher than non-participants) for disadvantaged fifth and sixth graders in a Northern Califoirnia black community. More frequent CAI experience led to higher gains. Because particpants were in their second year of CAI, the novelty of using computers could not be used to explain the results.

Fourth and fifth graders in San Diego who received CAI in mathematics scored higher than a control group on a district-made criterion-referenced test. Similar results were also obtained on a standardized norm-referenced mathematics test (Mills, 1979).

Romero (1980) conducted a controlled study of CAI with middle school mathematics students who scored below average on the Metropolitan Advanced Mathematics Test Series. The group which used the CAI mathematics laboratory gained significantly more in mathematics achievement than did students with only traditional instruction.

CAI drill and practice proved superior to workbooks in helping increase computational ability for remedial ninth, tenth, and eleventh grade students in a study conducted by Modisett (1980). Vincent (1977, 1979) found that EMR high school students using CAI for mathematics drill and practice achieved more than other EMR students.

Haberman (1977) studied the effects of CAI on emotionally and socially disturbed children who had been excluded from their regular classrooms. After two months, the CAI group had gained significantly more in grade equivalent than the control group.

A tutorial approach in algebra was reported by Pachter (1979). The CAI group was more successful in factoring second degree polynomials than the control group.

Other Subjects

Although the literature contains descriptions of many uses of CAI simulations in various social studies courses, few research results are reported. In one available study, Wilkinson (1979), found higher scores in social studies for junior high students who received supplementary CAI.

Dunkum (1979) found no difference in achievement when physics lectures were supplemented with computer simulations. However, it was discovered that teacher verbal dominance of the classroom decreased, student responsiveness and participation increased, and teacher receptiveness to student statements increased.

Several attempts have been made to present career information and guidance with CAI systems. Central Texas College (1973) combined tutorial CAI and videotape for eighth grade students in a Dallas middle school who were two or more years below grade level in reading on the CTBS. Emphasis was on Spanish-surnamed students, but learning increases were evenly distributed among blacks, Anglos, and Mexican-Americans with black females showing the largest gains.

In another study, high school sophomores who used a computer-assisted career guidance system scored significantly higher on all areas of vocational maturity as measured by Career Development Inventory (Drake, 1978). Cassie (1976) also found that a CAI guidance information system increased career maturity attitude.

CAI has been used to teach the fundamentals of foreign languages. One study found no significant difference in achievement between a CAI group and a control group of high school sophomores studying beginning French. McEwen and Robinson (1976) point out the efficiency of CAI, however, since the CAI students spent 30 hours less in instruction. Another study involved beginning German at the college level. In a carefully controlled study at the Air Force Academy, Schaeffer (1979) observed that certain types of CAI drill and practice produced results in semantic meaning which were superior to the control group.

The preponderance of data indicates that CAI can be an effective means of supplementing regular classroom instruction. Most studies deal with reading, language arts, and mathematics skills, but the few reported studies in other subject fields also indicate the effectiveness of CAI instruction.

ATTITUDE/MOTIVATION

How will students react to using computers? Will teachers object to working with an electronic machine? The answers to these and similar questions are important considerations when deciding whether or not to use computers in instruction. The problem is that attitudes toward a class, subject, teacher, or school have been measured in a definitive manner even less frequently than has achievement.

Thomas (1979) found ten studies to review at the elementary and secondary levels. Those studies indicated that CAI students have either the same or a more positive attitude toward the instructional situation.

More recent studies of attitudes toward CAI follow the same pattern. Ragosta et al. (1980) report that fourth, fifth, and sixth grade students were enthusiastic toward CAI and complained if a CAI lesson was cancelled. Teachers were positive about the addition of CAI to the curriculum. In addition to academic achievement, the computer helped to provide a certain type of discipline; students were aware that good concentration helped to improve their scores. Students with short attention spans found the short problems and immediate feedback to be valuable.

How do students react when they discover that part of their instruction will use computers? Beck (1979b) studied reactions of high school students with no previous computer experience who were told at the beginning of the course that they would be using a computer for portions of American History, Algebra I, and Computer Science. Computer Science students were significantly more positive toward CAI than students in American History, with Algebra I students in the middle. Nothing was mentioned about thow these pre-attitudes correlated with achievements in the courses.

Maser et al. (1977) reported a high level of satisfaction from students, parents, participating teachers, and the faculty in general throughout grades 2-9.

Mravetz (1980) found no difference in self-concept between students who used CAI and those who did not, but results showed that CAI students shifted their levels of aspiration toward more realistic learning choices. Improved attitudes of individual responsibility and realistic decisions for learning were attributed to encouragement given by the CAI process.

The most thorough study available of attitudes developing from the instructonal use of computers was done by Deblassio (1978). Three-fourths of the students in advanced high school mathematics thought that the computer helped them to learn and nearly 90 percent thought using a computer was a favorable experience. Significant differences were found in personal characteristics between the students who were most favorable toward using a computer and those who were least favorable. The students most favorable were:

- favorable toward the overall instructional setting;
- high achievers in mathematics;

- above average in their liking of problems involving original thinking;
- above average in their amount of vigor.

Students who disliked using the computer were:

- unfavorable toward the overall instructional setting;
- average in their liking of problems involving original thinking
- average in their amount of vigor
- likely to be more cautious and anxious than students who liked using the computer.

Casner (1977) explored the reactions of urban eighth graders to CAI in mathematics. No significant differences in attitude toward mathematics betwen CAI and traditional instruction were shown by females, but males in CAI classes were:

- less frightened by mathematics problems;
- less nervous at the prospect of having to do math problems;
- less likely to dread mathematics class;
- more likely to consider mathematics as fun.

Menis, Snyder, and Ben Kahan (1980) used CAI in tenth grade algebra with low achieving students who disliked mathematics. Not only did the CAI students improve their mathematics grades, but became less likely than the control group to report negative attitudes about mathematics and a variety of school-related issues at the end of the year.

Smith and Hess (1972) reported that CAI helped to promote the formation of realistic attitudes toward self-appraisal of junior high students' abilities in mathematics. Participants were predominantly Mexican-Americans who were initially two-to-three years below grade level in mathematics.

Compared to students in ordinary classes, Romero (1980) found positive shifts in student interest, conduct, and behavior patterns for low achievers in middle school mathematics who had CAI.

Vincent (1977, 1979) concluded that EMR high school students who had CAI in mathematics and reading had a more positive attitude toward those subjects than similar students without CAI.

Beck (1979a) reported student attitudes toward CAI in a sample of Nebraska high schools. Predominant usage was in computer science, mathematics, and various sciences. Females were significantly higher in attitude toward CAI. Attitude toward CAI was found to be related to certain personality traits of the student. Students who were more self-directed tended to be more favorable toward CAI.

Middle school students who were given career information by CAI and videotape had a positive attitude toward the experience (Central Texas College, 1973). Class attendance was higher for the CAI group, and students were enthusiastic toward the immediate feedback received from CAI.

Taylor (1979) surveyed students who received CAI in beginning German. A large majority thought of the computer as their private tutor. Eighty-six percent of the students agreed that the grammar learned in class was reinforced by the CAI explanations.

A few studies, such as Anelli (1978), report that enthusiasm was extremely high for CAI, but leveled off after either a long or short experience. However, most of these studies fail to indicate any hard data upon which these decisions were based. On the other hand, Wells et al. (1974) found that elementary students in their second year of CAI were enthusiastic about the experience. Smith and Hess (1972) found no difference in the pattern of results between students in their second successive year of CAI and those experiencing it for the first time. Many other studies and reports indicate that students had positive attitudes about CAI, but do not indicate how this conclusion was determined.

TIME REDUCTION

Claims have been made that the use of CAI will reduce the amount of time needed to learn a concept. Edwards et al. (1975) summarized nine studies which indicated that CAI students learned as much or more than students in traditional instruction, but that the time taken for a student to achieve equal results was reduced. Eight of the nine studies were at the elementary level. Thomas' survey of ten studies concluded that at both elementary and secondary levels CAI reduces the amount of time required for a student to complete a unit.

Current literature contains many references to the time saving benefit of CAI, but only one report of research at the elementary and secondary levels was located which documented the time savings. McEwen and Robinson (1976) reported that beginning French students who received CAI spent about 30 less hours in classroom instruction, but achieved at the same level.

RETENTION OF MATERIAL

Impressive results which attest to the effectivenss of CAI have been described. These comparisons have generally been based on results attained at the end of a certain period of instruction. What about the student's retention of material over a longer period of time?

Edwards et al. (1975) found that two of three reported studies indicated that CAI students retained material less well than the non-CAI students. Both of the studies reported by Thoms (1979) indicated retention of learned materials which was about the same for CAI and non-CAI students. Litman's study (1977) of remedial readers showed that males receiving CAI maintained their advantage over non-CAI males when retested after two years.

As in other educational endeavors, the amount of data relating effects of CAI and retention of material is sparse. The data which do exist are inconclusive concerning whether CAI helps students retain more of what is learned than do students receiving traditional instruction.

TEACHER-STUDENT INTERACTION

Fears have been expressed that the use of computers in the classroom would decrease the amount of teacher-student interaction. Three studies measured the interaction of teachers and students while CAI was being used to supplement regular instruction. Dunkum (1979) discovered that physics teachers lectured less, provided less negative feedback to students, and were more accepting of student responses than the same teacher during a similar class without CAI. The variety of teacher-student interaction increased for CAI classes. Haberman (1977) found that EMR high school students using CAI did not receive as much teacher attention as students receiving only traditional approaches. Students increased their self-reliance. Romero (1980) reported that CAI helped to lesson the teacher's duties in middle school mathematics which led to more productive student-teacher interaction.

SUMMARY

The data indicate that CAI which supplements traditional instruction is effective in increasing learning by elementary and secondary students. In fact, the weight of evidence is overwhelming in favor of CAI. Not only has CAI been shown to contribute to higher student achievement, but there is evidence of positive student acceptance of the use of computers in the classroom. Although research is sparse, it also appears that CAI can decrease the time required to learn subject matter.

Unanswered questions exist relative to long-term retention of learned material and teacher-student interaction. These areas have been researched more frequently at the collegiate level with generally positive results, but little acceptable research has been done at the elementary and secondary levels.

Taken as a whole, the literature indicates that CAI is effecitve in helping students learn when used as a supplement to regular instruction.

A REVIEW OF RESEARCH ON EFFECTIVENESS OF NON-COMPUTER ELECTRONIC MEDIA IN TEACHING BASIC SKILLS

This review of research relevant to the teaching of basic skills in primary and secondary education focuses on educationally-relevant electronic media other than computer technology, specifically television and radio technology.

The selection of media focused on in this report excludes two significant new instructional technologies. First, videodisc as an instructional technology is a very recent development, and no significant research on its effectiveness as an instructional medium has been published. A description of its present status is included in the "State of the Art in Instructional Technology" section of this report.

Second, computer managed instruction (in which the computer is used for such support tasks as record-keeping, diagnosing and tracking students) has been insufficiently researched as a technology impacting student achievement to allow for any conclusive assessment of its effectiveness in this area.

METHODOLOGY

As the main source of literature on primary and secondary level basic skills instruction using electronic non-computer technology, a complete Educational Resources Information Center (ERIC) search was made using over 20 descriptors to capture relevant references. The search provided a list of just over 100 references, of which 25 were determined to be directly relevant to primary and secondary instruction in basic skills using, specifically, electronic media for instruction. Of these, only nine documents were found to provide substantial research or review information.

To supplement this search, educational periodicals focusing on instructional technology and/or basic skills were scanned for relevant reports; no additional substantially informative documents were located in this effort. Finally, the two literature reviews listed in the ERIC search were scrutinized for relevant reports not yet uncovered. The document, "Technology and Reading, An ERIC Report," by Winkeljohann (1973) listed seven references, none of which were specifically related to either basic skills or electronic instructional media; the lengthy review "Teaching Reading with Television: A Review," by Mason and Mize (1978) listed 49 references, most of which related to reading readiness through television viewing for pre-school children and only two of which were judged relevant to this review.

A recently compiled annotated bibliography by Dillingofski (1979) is an excellent compendium of the effectiveness of audio, visual, film, television, and CAI in the teaching of reading. That compendium is briefly summarized here, and the reader is referred to the complete document for a more detailed treatment.

Use of the audio (tape recordings) medium alone in the reading curriculum is skimpily researched. Audio combined with printed texts provides effective reinforcement for those students whose reading skills are not yet fully developed or whose motivation to read is low. Some reading skills (comprehension, rate, and attention span) are improved through this multisensory approach.

The area of visual media (slides and still pictures) in the reading program has not been extensively researched.

The review of research on the use of film to improve specific reading skills yields surprisingly few studies. No firm conclusion can be drawn regarding learning reading skills from film.

A growing amount of empirical evidence is available, however, on the use of television to improve specific reading skills. It appears that commercial television programs can form the basis for teacher-developed lessons on specific reading skills.

Research based on studies of "Sesame Street" and "The Electric Company" seems to support the position that, while the gains in reading readiness may not be as great as originally reported, pre-school viewers can make gains in several areas, particularly in letter and number recognition.

Locally produced television programs and videotapes to increase specific reading skill's produce gains in skills when the instructional design of the program provides for participation, feedback, and transfer. Both film and television are effective for learning principles, concepts, and rules.

Many questions remain to be answered regarding the effectiveness of television to teach specific reading skills, particularly in the area of pictures vs. print vs. spoken language.

In all, the literature on basic skills instruction for primary and secondary students using electronic instructional technology is, as yet, very sparse, with only 11 relevant studies located for this report, although reference is made to a few tangentially related studies as well.

The research reported in the relevant documents has not been closely evaluated from the point of view of research techniques: acceptable use of coherent design, data collection method and/or concluding evaluation were considered to be basic requirements met by each of the studies reviewed here.

RESEARCH REVIEW

Television

In the last decade television has been subjected to increasing scrutiny as a possible variable in the situation of declining SAT scores in reading and of increased hyperactivity among children. The current ERIC listing includes six reports on possible relationships between casual (home-based) television viewing and children's reading achievement. Of these, List (1978), Williams (1979), Busch (1978), and

Fisher (1976) report negative correlations between reading achievement and home television viewing. Mercer (1980)) reports such correlation for children in two of the six grades studied, and Winter (1980) suggests the implication that major television network programming may be conditioning children not to read or write for enjoyment or for the improvement of these skills. Further, as reported by Levinsohn (1977) educators are questioning the effect of the fast-paced children's television shows such as "Sesame Street" on children's attention spans, ability to resist distraction and ability to sit still.

Assuming that this possible connection of television viewing to reading and behavioral problems is related primarily to casually-oriented television programming which is not guided by curricular or instructional design, the medium of television is continuing to be explored as a potentially useful instructional technology under conditions of educational programming and curricular relevance. Mason (1978) cites several early studies (1950s and 1960s) investigating the effectiveness of television for instructional purposes with pre-school children which pointed to some significant gains in reading readiness of achievement under specific conditions--for example, when immediate reinforcement activities or feedback were provided by parent or teacher. Mason further cites an evaluation (not reviewed here) by Bill and Bogatz in 1973 of "The Electric Company" children's television series which determined that, in eight experiments with classes in grades one, two, three, and four, classes which viewed the television series earned larger gains in reading achievement scores that non-viewing classes with which they had been matched. Children in one-half of the target groups (i.e.. first graders and low-achieving second graders) were noted to have made significantly greater gains than non-target students. Although these early findings are not highly significant, they stood out as indications to educators of the potential instructional capability of television.

While noting some of the major shortcomings in technique and production of available educational television programming, the more recent report by Levinsohn (1977) describes the positive success achieved by instructional television when introduced into middle-grade classrooms in El Salvador; the overall evaluation indicates that the television-class students scored from 15 to 25 percent higher on general ability tests than students who received no television instruction. Levinsohn notes that in the El Salvador instructional television experience and others like it where many of the schools involved are rural and poor in resources, television instruction can improve and/or enrich the educational opportunities available to the children.

Specifically, relevant to the teaching of basic skills, a study by Harvey (1976) reports on the successful use of the mathematics "Infinity Factory" programs developed to teach children ages 8 through 11 some basic mathematics skills of everyday life. The study using over 1000 third-to-sixth graders found that the series was effective in teaching the math knowledge and holding students' attention; it was also found that teachers considered the programs to be both effective and useful. Another study, Teachman (1978) reports that "Math Patrol," a primary level curriculum-based math program was found to be effective in increasing second grade children's comprehension of math and in providing a high degree of motivation for students.

Two additional reports suggest collateral implications for the use of television in the teaching of basic skills. In a six-week experiment with 253 New Jersey seventh graders, Hamilton (1976) notes that when given a choice of reading or not reading books related to favorite television programs, more students chose to read television-related books than non-related books. The ratio was an average of 7.54 tie-in (television-related) to 3.07 books not related to television. Hamilton concludes that students will read when their interests are engaged. This suggests that tying readings to appropriate (and motivating) instructional television programs could enhance development of basic reading and language arts skills.

Further, Basemore (1978) reports on the Rand-Spartanburg Two-Way Cable Television Project, with its resulting success in providing instructon in GED and pre-GED skills. Thirty-three percent of the students enrolled in the GED class passed the GED exam in the spring of 1977 as compared with 18 percent of the students in the conventional GED class, and 20 percent of the television class dropped out as compared to a 37 percent drop-out rate for the conventional class. Although the numbers of students involved in this project were small (10 in the television class and 22 in the conventional class) the results still have a comparative signficance, especially when the surrounding community (with 62 percent of its adults over 25 years lacking high school education) is taken into consideration. This project, utilizing with success the two-way capability of recent television technology, highlights another promising aspect of television in basic skills instructional application: the interactive capability of such programming can provide the student participation which educators have long considered highly important in learning and retention--for example, Levinsohn (1977).

Radio

In his 1975 paper "Instructional Radio: An International Perspective" Theroux provides a supportive review of radio-based instructional programs used in a variety of countries including the United States. He concludes that the characteristics of relatively low cost, effectiveness of instructional format at least equivalent to traditional instruction, and the availability of radios make this technology a highly viable medium for instruction. Included in Theroux's paper is a description of the outstanding recent project involving radios in instruction: the Nicaraguan Project.

Suppes (1978) reports in detail on the successful use of instructional radio to teach primary school mathematics in rural Nicaragua. This carefully designed and controlled project resulted in an impressive accomplishment: radio class students achieved a mean post-test item score approximately 25 percentage points higher than the mean item score for the control group. Among the many important aspects to the instructional format, two particular features are important to point out in view of preceding observations noted in this report:

1. Emphasis was given in this project to the active participation by children prior to, during, and after the radio lessons.

2. Feedback in the form of correct answers was immediately provided in the radio lessons.

FUTURE TRENDS AND POTENTIAL OF TECHNOLOGY IN BASIC SKILLS INSTRUCTION

WHAT IS NEEDED

Instruction and remediation in the basic skills can be accomplished effectively with the art of technology. Never before has such an array of instructional delivery alternatives been available to educators. If we were to list some of the characteristcs of an "ideal" delivery system for basic skills instruction (aside from warm, caring, patient human teachers with time to tutor each child individually), we would include the following:

- Careful instructional design, incorporating an entry level skills test, specified student outcomes, and performance criteria
- Diagnostic and error analysis capabilities
- Automatic record keeping for each child and group
- Adaptability to a child's individual learning style and rate
- Full array of appropriate visual stimuli
- Capability of providing auditory stimuli
- Ability to maintain a high level of student involvement, interest, and motivation
- Fully interactive
- Reinforcement provided for correct response; impartial, patient and unemotional feedback provided for incorrect response

The new technologies allow us to achieve all of these requisites and more; they allow us to actively engage the child in learning for longer and longer periods of time, freeing the teacher for a new role as a manager of instruction and for working as tutors with individual students.

Future trends in instructional technology are based on two revolutionary developments: the increasingly inexpensive microcomputer with its television screen display, and the use of telecommunications to interconnect computers with each other and with data bases of information and software. The coupling of the videodisc with the microcomputer adds a rich dimension to this capability.

Technological systems for remediation of basic skills will take advantage of these capabilities in the near future. Beyond that, however, there are tremendous implications for the entire institutional structure of education. Some educators (Melmed, 1980; Bork, 1979) suggest that a radical restructuring of schooling is not only newly possible but probable in the 1990s, with education taking place in the home, library, and work place rather than exclusively in the school.

The "ideal" system for basic skills remediation would include a microcomputer with diskette and color television screen, interfaced to one or both of the following:

1. A telecommunications network giving access to basic skills courseware stored on large computer systems at other sites, and downloaded to the user's microcomputer for local delivery of instruction.

2. A videodisc unit storing courseware in the form of CAI programs, still pictures and video and audio segments.

The system would keep progress records on each child, diagnose and prescribe, adjust to each child's learning rate and style, and provide constant interaction, feedback, and reinforcement. The visual and auditory capabilities of the computer/videodisc would be used appropriately in providing basic skills remediation.

A significant implication of the scenario described above is the effort and resources that must go into instructional design to take full advantage of the technology in meeting the needs of the learners.

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THE "INCREDIBLE COMPUTER"

Inside Education. New York State Education Department.
Vol. 67, No. 4, January-February, 1981

While advances in microelectronics make the computer more and more enticing, educators must learn to use it well if the computer is to fulfill its promise.

"This instrument can teach, it can illuminate: yes, it can even inspire. But it can do so only to the extent that humans are determined to use it to those ends. Otherwise, it is merely lights and wires in a box."

Edward R. Murrow said that, not about the computer, but about his favorite subject, television. He said it in 1958, when the computer was still a vacuum tube baby, larger than the average living room and probably 100 times more expensive than the furniture.

With help from the transistor and the silicon chip, the computer grew, over the next 20 years, into a darling of microelectronics. From the size of a bus to the size of a typewriter, from hundreds of thousands of dollars to a thousand or less, the computer turned into a genius that would fit into the homes and the budgets of ordinary people.

It also fit more easily into classrooms and school budgets. From a starting point of zero when microcomputers were first introduced four years ago, there are now more than 7,000 of them in New York State schools.

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Astonishing growth.

Yet without the skill and determination to tap its potential, the sophisticated computer of the 1980's, like the television set, is still nothing more than an electronic bauble. And, there is good reason to doubt that its mere proliferation will produce widespread, long-term gains for education.

As with most things, one of the chief barriers is cost:

- The cost, first of all, of training teachers and administrators to use the computer well.
- The cost of quality courseware. While the microcomputer brought the initial investment for computers within the reach of most school districts, developing quality courseware--the programs that run the machines and help teach the students--is still expensive and likely to remain so. Because computer use is on the increase, demand for courseware also is on the increase and there are still relatively few people with the skills to do it well.
- The cost of maintaining and updating equipment as well as courseware, both of which become outdated rapidly. For example, the most powerful computer in use today, capable of 80 million operations per second, will be obsolete--a candidate for the junk pile--within five years.

Unfortunately, all of these costs come at a time when financial resources for schools are on the decline and pressures to justify new as well as old programs are intense.

In testimony before the State Senate Education Committee this February, Education Commissioner Gordon M. Ambach emphasized the need for statewide support and coordination of computer efforts to make them pay off. Without that support and coordination, he said:

> Thousands of computers probably will be bought by school districts. Most will be bought by the more affluent districts where parents will demand the "best" and the "latest" for their children. . . .
>
> Some districts will use them well. Most will find that acquiring quality courseware, maintaining teacher skills and enthusiasm, and maintaining and replacing equipment will be too costly on an on-going basis.

> Instructional materials will not live up to expectations because, with each school district buying on its own, no (single) producer will be willing to invest the funds necessary to produce quality materials.
>
> While schools struggle to make as good use as they can of computers, home and workplace uses will grow. As with television, computers will then influence education more by how they are used outside of schools than how they are used within them.

If used well, however, computers and education can have a mutually advantageous relationship.

What better institution is there, for example, to provide computer skills on a broad scale? Industry may provide those skills to some, but what about the countless others who could benefit? And what about those who, without the needed skills, will be "illiterates" in the fast-moving, computer-based "information society" sociologists predict for the coming decades?

The speed of development in computer technology, and its complexity, threaten to divide people into "technocrats" and "techno/peasants," those who can keep up with change (and, thus, to a certain extent control it), and those who cannot. Education has an obvious mission to close the gap.

Just to give one small example of the educational implications of the computer: The last time you bought a meal at one of those fast-food restaurants, a computer probably recorded the price of each item, added up the bill, computed the tax and printed the receipt. While at first blush you may wonder what that does for basic math skills, the U.S. Institute of Electrical and Computer Engineers estimates that there are half a million programmers in this country now working on computer systems like that. By 1985, the Institute estimates that industry will need 2.5 million programmers--with highly developed math skills--to work on similar systems.

Who will train them?

"For the first time, we have the chance to be in on the leading edge of technology," says Gary Becker, director of educational communications for Fayetteville-Manlius Schools and an adjunct professor of communications for Syracuse University.

> One thing is for sure, use of the computer is going to grow, with or without us. We can either promote its proper and healthy growth, and help our kids deal with it, or we can ignore it.
>
> The real world out there will want the skills, and if it can't find them in the traditional school system, it will find them someplace else.

Beyond implications for the job market, the computer has the potential to change education itself. As Murrow put the case for television, the computer can teach, illuminate and inspire.

In the hands of a teacher who knows how to use it, the computer can support almost any educational goal. For the gifted and talented, the computer can simulate normally out-of-reach worlds and provide a way to change them experimentally. For the handicapped, the computer can provide a way to control the heretofore uncontrollable. As a classroom manager, the computer can help teachers test and drill students and keep records in far more detail--and with far less effort--than ever before. And for administrators at all levels, the computer can help manage the business of education.

One of the great strengths of computer learning is that it is interactive. When programmed well for drill, practice and testing, the computer can respond to and guide students with a great deal of skill. Rather than depersonalizing education, as some people fear, the computer actually can add more effective human contact by freeing the teacher from the mundane tasks of education to zero in on the needs of individuals.

The greatest strength of the computer, however, lies beyond drill and practice, when students and teachers teach the computer--write programs for it--and, then in the words of Thomas Dwyer, a professor of computer science at the University of Pittsburgh, become "codiscoverers of truth."

"We have found," says Dwyer, who led several National Science Foundation projects on ways to link computer instruction with the high school curriculum, "that computing, in the hands of well-supported teachers and students, can be an agent for catalyzing educational accomplishment of a kind that is without precedent. We believe that there has simply been no other tool like it in the history of education."

Undoubtedly, the computer's potential to help teachers is one reason for its sudden proliferation in schools.

Linked with other technological innovations, the possibilities seem endless. For example, when linked with the laser disc--a kind of light recording that is cheap to produce, capable of storing large amounts of information and now becoming widely available for use with common television sets--dramatic reenactment of material is possible, along with testing, tutoring and record keeping capabilities.

Linked with the push-button telephone, the computer has the ability to call a student at night, give homework questions based on results of work done in the classroom that day, and receive answers.

Linked through acoustic couplers to common telephone lines, computers can "talk" to one another, allowing small computers to tap the capacity of larger ones and opening up vast information networks.

To be sure, the day of space-age learning at home in front of a television console--only a futurist's pipe-dream a few years ago--is close at hand.

The critical question at this point, however, is not what the technology can do, but how we can most effectively organize to make the most of its capabilities.

Here are some suggestions:

- There must be more communication among individual users of the technology so that what has been done well in one part of the state or nation can be shared with those who have similar needs. This year for the first time, SED has required that the 44 BOCES in the state develop long-range plans for computer use in cooperation with local school districts. While there is some evidence that BOCES and districts already share information, it occurs largely on an ad hoc basis and there is a lot of room for improvement.

- There must be a system for assessing grass roots courseware. With the rise of mini- and microcomputers, teachers and students now are able to produce their own courseware. Some of it is good and warrants wider distribution, but there must be a way to determine the merit and applicability of locally produced work.

- There must be systematic cooperation in the purchase of commercially produced courseware. Such a system could be similar to the one now used to acquire commercially produced instructional films. Under that system, school district representatives, working through BOCES, decide which films they need. The state then negotiates for the rights to reproduce the films on videotape and distributes the tapes. Because many districts participate, the cost of acquisition has been reduced 60 to 75 percent.

- There must be a cooperative effort to assess the benefits, costs and effectiveness of different hardware, technology and approaches. These assessments can help guide state and local policies.

To help carry out these goals, the State Education Department is in the process of creating a Center for Instructional Uses of Computers. The Center will work on these specific tasks:

- To promote computer awareness and literacy for all students

- To promote inservice and college level training programs for teachers and administrators

- To encourage development and distribution of quality courseware

- To promote shared acquisition of hardware and software
- To encourage studies on cost benefits of new techniques
- To coordinate information on the state-of-the-art

Despite its meteoric rise in the last 5 to 10 years, computer use still is in a relatively primitive state.

"While we are at the very beginning," says Alfred Bork, a University of California professor of information and computer sciences, "the pace will pick up rapidly over the next 15 years. By the year 2000, the major way of learning at all levels and in almost all subject areas, will be through interactive use of computers."

Advocates such as Bork compare the computer with the printing press and point out that it was more than 200 years after the invention of the printing press that textbooks came into widespread use at colleges and universities. Those who benefited most from the printing press initially were those from the privileged classes who already could read. The full impact of the invention only came after schools created a wider range of literate people.

By comparison, development of the computer will be far more rapid. Once again, however, the critical task for schools is to develop the broadest possible range of people who can benefit.

Profiles

PROFILES OF MICROCOMPUTER USE IN SELECTED NORTHWEST SCHOOLS

For an educator who is considering implementation of some microcomputer-oriented application in school(s), the single most important piece of advice offerred by users is to plan an intensive on-site visit to a school or district where the application is currently in use. If the exact implementation is not available, visit a site that is applying a closely related concept. Educators are generally willing to help you avoid duplicating their mistakes.

To help you carry out that advice, staff of Northwest Regional Educational Laboratory have compiled the following profiles. Each profile was based on a telephone interview conducted during the middle of October 1981. We have provided a contact name and number so that you can follow up on any of these examples that you wish. The time and resources to do a full scale project on this have not been available, so it is possible that some excellent examples have been overlooked.. For this reason, we have provided space in this section for you to add your own list from contacts you have made here and elsewhere.

MATH INSTRUCTION FOR BASIC SKILLS PROJECT (MIBS)

CONTACT PERSON:

Mrs. Dale B. Golis, Principal or
Andy Moore, Project Coordinator
A. B. McDonald Elementary School
Moscow Public Schools
P. O. Box 3459
Moscow, Idaho 83843
(208) 882-0228

DESCRIPTION OF PROJECT:

This project, designed to augment individualized math instruction for high risk learners, was implemented in Moscow (Idaho) Public Schools in 1980. Special education students in grades 4, 5 and 6 with math skill deficiencies identified through a needs assessment are eligible for project participation. Significant math score gains (using standardized pre and post tests) have been noted for all groups using the program, especially high risk students. The project is being further developed to include programs in problem solving, measurement, and time telling.

HARDWARE:

- 6 TRS-80 with disk drives and a networker.
- 1 APPLE-II plus with printer.

A deliberate decision was made not to tie the program to one type of hardware. The district is anticipating much growth soon, and is considering a Micro to Mini link up for computer literacy programs.

SOFTWARE:

Initially, staff used only commercial software from Dallas (Texas) ISD. However, they eventually began to develop their own programs to meet specific educational needs and at present are using a combination of commercial and self-developed programs.

PERSONNEL:

Staff were paid to attend inservice classes held after school and on Saturdays. Initially, teachers were disinterested or fearful, however, they became enthusiastic and supportive after receiving inservice training. The cost factor was a concern to staff until program costs were compared to the costs of purchasing textbooks. In this context, cost became less of a concern. Community response has been favorable.

COST:

During 1980 the project was funded through a Title IV-C developmental grant for $25,977. This year a Title IV-C grant for $22,000 was awarded for continuation of the project.

RECOMMENDATIONS/COMMENTS:

Project personnel stress that teacher familiarity with the project is a critical factor in its successful implementation. Teachers must be comfortable with the machines and program and know how to use the technology properly.

The district encourages other interested parties to use the program. The commercial component may be purchased directly from the Dallas ISD (Dallas, Texas).

RESOURCES:

Northwest Regional Educational Laboratory
Harvard Catalogue "Microcomputer Directory"

REMEDIAL CAI PROJECT

CONTACT PERSON: Vern Johnson or Jay Davis, Consultant in Instructional Computers

Highline School District
15675 Ambaum Blvd., S.W.
Seattle, WA 98166
(206) 433-2340

Jay Davis, Consultant in
Instructional Computers
(206) 433-2334

DESCRIPTION OF PROJECT:

A project providing CAI to all Title I, special education and handicapped students with skill deficiencies in language arts, math, and reading was implemented in Highline School District three years ago. Impetus for the project came from a conference attended by staff in 1968. At that time the district tried some low-level time sharing that was not successful because the response time was too long. In 1973-74 the Remedial CAI project was funded for 3 years by a Title I grant and implemented in Title I schools. Success of the project over a three-year period has been demonstrated by student growth on achievement tests. Typically, pre CAI student progress was .4 or .5 years growth per academic year; with CAI, student progress is, on the average, 1.2 years per academic year. The greatest growth is in grades 4-7 in language arts followed by math and reading. At present, budgeting concerns place the program on hold. However, the district expects that it will expand into more use with specialized programs, e.g., programs for the deaf.

HARDWARE:

- 78 timesharing terminals on a "CCC 17" Lost (actually a Data General Nova 3). Terminals are allocated to schools on a per student basis and range from 1 to 16 per school.

- In addition there is a DEC 11/03 in the high schools for computer literacy/computer programming courses.

SOFTWARE:

1. Advantages: Royalty for software use is paid; any course the project support is available ($200/terminal); courses are comprehensive and have been field tested; all support is provided

2. Limitations: Fairly expensive; must arrange the non computer part of the programs to the software

PERSONNEL:

Aides, teachers and administrators were provided inservice training during the school year (2-4 hours during school hours at union request). At present, there is one project coordinator who works 1/4 to 1/3 time. Teacher aides and parent volunteers work with students and keep an eye on the terminals (4 or more terminals require the assistance of an aide). Initially, staff resisted the notion of CAI however, once they were able to see student growth, they began to accept its use. Intensive person-to-person contact by the consultant, plus faculty meetings and inservice classes made staff more responsive to the project. Community support has been very good. The district maintains an open policy of allowing anyone to visit and observe the project.

COST:

The project was funded for three years (1974-77) through a Title I grant. Since that time, the district has defrayed the cost of the project.

RECOMMENDATIONS/COMMENTS:

1. When putting CAI into a school system, develop a structured plan for implementation; the program must be carefully laid out in advance.

2. A CAI project must be tailored to meet the specific needs of each school; one plan will not work for the entire district.

3. It is critical that time be allocated to helping staff grow into the system.

4. The district recommends that others try a comprehensive program of this nature, especially if there is not a great deal of money available for development of programs and staff development.

5. The district encourages that others visit districts where CAI has been implemented before designing their own program.

COMPUTER LITERACY PROJECT

CONTACT PERSON: Al Olson
Hillsboro Union High School District
Hillsboro, Oregon
(503) 640-4604

DESCRIPTION OF PROJECT:

A computer literacy project was implemented two years ago in ninth grade math classes in the Hillsboro Union High School District. Since that time the project has expanded to include an introductory course in computers for tenth grade students and two levels of computer programming for students in grades eleven and twelve. School personnel and members of the community were responsible for initiating the project and assisting in its implementation. Although no formal evaluation has been conducted, teachers have indicated that the project is successful with students. An electronics/vocational program is currently under development.

HARDWARE:

(Junior High Schools)
- 3 schools: PET 16K
- 1 school Apple II

This hardware was purchased specifically for this project. There are 15 micros in each building that are rotated within the Math Department. They are all in use for the full day until Christmas, at which time they are dispersed among the math rooms and use is determined by each teacher. In addition, each library has one micro for student use full time, and the science divisions each have one micro for science and energy simulations.

At the senior high school level the computer programming courses use 16 terminals timeshared at the ESD. However, they are planning to move to microcomputers here as well.

SOFTWARE:

Students write their own programs. In addition, some software, including games and tapes which provide a "walk through introduction to microcomputers, has been acquired."

PERSONNEL:

Several district inservices were provided prior to implementation of the project. These included one evening workshop for math teachers, principals and interested staff, three evening sessions for interested staff from other schools, and classes for credit on computer awareness and computer application. Inservice was also provided for office staff and secretaries. Evening classes are presently being developed for interested parents.

COST:

The project is funded totally by the District, although some Title IV grant funds provided the library and science machines. Expenditure for inservice is kept to a minimum by using the voluntary and enthusiastic assistance of the teachers involved.

ADMINISTRATION AND INSTRUCTION: TOTAL PROGRAM

CONTACT PERSON:
Jerry Larer, Director of Computer Services
North Clackamas School District
14211 S.E. Johnson Road
Milwaukie, OR 97222
(503) 653-3827

DESCRIPTION OF PROJECT:

A comprehensive administrative and instructional computer project was implemented in North Clackamas School District in 1975 (timeshare since 1978; micros since 1975). The instructional component includes computer literacy, computer science, and a small amount of CAI. The administrative component includes data collection relating to attendance, energy consumption, new construction, personnel, work and service orders, scheduling, timetabling maintenance, and the transportation department. The project was initially funded through an OMEC grant and student funds. Although a formal evaluation has not been conducted, the district feels the project has been successful because it has continually grown since its inception. The district is committed to this growth and has formed an Instructional Computer Services Committee to monitor and upgrade all aspects of the project.

HARDWARE:

Student Use: Microcomputers: 25 Apple II, 15 Pet. 3 TRS-80, plus selected others
70 terminals timeshared on a DEC 1170
Administrative: 37 terminals timeshared on the DEC 1170

SOFTWARE:

According to district personnel, most available CAI coursework is not designed adequately for student use. The district has developed its own administrative program for attendance, energy consumption, new construction, personnel, work and service orders, maintenance, and the transportation department. They purchased a scheduling and timetabling package.

PERSONNEL:

Evening inservice classes and workshops are provided through DCE for personnel involved in implementing either component of the project. As an initial grass roots effort, the project met with wide staff and community acceptance. This support has only recently been attenuated due to funding problems.

COST:

Initially the project, including teacher training, was supported through a grant by OMEC. A budget of $250,000 includes computer payment. Micros are generally purchased by individual schools, with contributions by PTAs.

RECOMMENDATIONS/COMMENTS:

1. Computers are cost effective; they provide better management of data faster, and will not eliminate personnel.
2. For the administrative component, simulations with staff are encouraged before actual runs.
3. The district highly recommends that other districts use both components of the project.

RESOURCES:

Consultants:

Dave Moursund (503) 686-4408
Dick Ricketts
Ron Tennyson

Journals:

Computing Teacher
Creative Computing
Interface Age
Byte

HARDWARE SELECTION PROCESS

CONTACT PERSON:
Wayne Neuberger
Beaverton School District #48
P.O. Box 200
Beaverton, OR 97075

DESCRIPTION OF PROJECT:

In 1978 Beaverton School District initiated a project that involved evaluating different microcomputers to be used in an educational setting. Administrators and teachers from all schools in the district were included in the hardware process. Although a formal evaluation of the selection process has not been conducted, district personnel indicate that the selection process has not received any negative reactions from administrators, teachers, or students. The district is currently reviewing instructional needs and may be purchasing additional equipment for specific instructional purposes

HARDWARE:

Each school evaluated a different microcomputer for one year--the result was a recommendation to standardize to a single system. There are presently 75 micros in use throughout the district in both secondary and elementary schools. Ten terminals are on timeshare through the ESD. Schools vary according to use time, ranging from "some idle time" to 100 percent usage. Within the district, student/machine ratio is 300:1; however, micros are predominantly used with large groups (regular class or remedial) for CAI where the ratio is 25-30:1.

SOFTWARE:

The only software aspect of this process was that the language of the machine was a consideration.

PERSONNEL:

District inservices classes were held to inform staff about the use of microcomputers in education. These included district-wide classes and school-site classes, conducted after school hours. Staff and community interest have generated continued support of the project.

COST:

The project was funded in part through the regular allocation of district funds. In addition, some funding was provided by parent groups and student body funds. The district has been able to reduce costs because of large scale purchases.

RECOMMENDATIONS/COMMENTS:

1. If a district has limited funds and wishes to expand, it is essential to purchase a standard machane.

2. Since elementary and secondary needs are different, a two-level decision process is encouraged.

3. The district has devised a checklist that is available to other districts.

4. When making a hardware selection decision, it is important to consider the purposes of the hardware.

COMPUTER LITERACY PROJECT

CONTACT PERSON: Linda Malone, Director of Computer Literacy Program
Bush Schools
405 36th Avenue East
Seattle, WA 98112
(206) 322-7978

DESCRIPTION OF PROJECT:

In 1976, a computer literacy program for grades K-12 was implemented in Bush Schools. The program was initially on teletypes timeshared to a mainframe, but has since been transferred to Datageneral Nova Mini and 7 terminals. Although the project was designed for use with a regular curriculum, it may also be used with a gifted program. The project includes programs in the following academic areas: math (problem solving), science (simulations), and P.E. (training needs/nutritional needs). The computer program is compulsory for students in Grade 8. A formal evaluation of the project has not been conducted, however, student and parent response have been favorable. The computer is in continual use and has become integrated into the school curriculum.

HARDWARE:

7 terminals on a Datageneral Nova 7 Minicomputer. This configuration is being phased out in favor of 9 TRS-80 Model I microcomputers networked together and one TRS-80 Colour Computer.

SOFTWARE:

Because software did not exist for the machine, the school had to develop its own to meet specific needs. While this has been seen as an advantage, it also creates a problem because programming is so time-consuming. In addition, there are not enough graphics for each program to be considered complete.

PERSONNEL:

Inservice training and summer workshops were offered to school staff and other interested teachers by the district computer staff. In addition, the computer staff (two half-time teachers) continue to offer their expertise on a one-to-one basis. This service has attenuated the initial "computer fear" experienced by many teachers. Administrators are verysupportive of the project and have encouraged staff computer awareness. Their support has helped to integrate the computer into the regular school mainstream.

COST:

A grant plus a family gift provided the initial funding for the project. The project is currently funded through allocations from the district operating budget. Additional costs include: hardware (printer), supplies, student operators and programmers.

RECOMMENDATIONS/COMMENTS:

1. Staff inservice training is critical for increasing computer awareness and knowledge and for reducing staff computer fear.

2. Before acquiring hardware it is important that the district and/or school develop specific project goals and objectives.

3. Staff should be trained as computer staff to avoid making the program dependent on one person.

4. This project is recommended for use as a broad-based computer literacy program.

5. This project is currently available through Creative Publications. The curriculum is not yet a document for publication or purchase; however, the district encourages visits from interested parties.

RESOURCES:

Computing Teacher
Byte
Creative Computing
Academic Computing Center, University of Washington
NWREL
Dave Moursand (503) 686-4408

BASIC SKILLS (EDUCATIONALLY DISADVANTAGED) PROJECT

CONTACT PERSON: Cliff Winkler
Medford School District
Medford, Oregon
(503) 776-8649

DESCRIPTION OF PROJECT:

In 1974 the Medford School District implemented a Title I "Multiple Attack on Educational Disadvantaged" project for students deficient in basic skills. Students scoring below the 29th percentile on the Stanford or Iowa Test of Basic Skills are eligible for the comprehensive Basic Skills program. Micros are used to augment regular instruction. One component of the project is CAI and includes both commercial and district-developed software (drills and games) in reading, math, and language concepts. The district will be converting to Compucolor. Success of the project has been demonstrated by student growth on achievement tests. The district has been able to document that a student must have a minimum of 14 hours per year in the project to succeed. They have identified certain problems that make the system difficult to maintain at a satisfactory level: manpower shortage and rapid hardware changes. They feel that advances in the field will not be made until micros are related to video discs; people will then buy either courses or a particular system. At present, the rapidly changing hardware preclude a project from keeping up-to-date.

HARDWARE:

Initially an HP 22000 mini supporting 90 timeshared terminals. In addition: 30 Compucolor Microcomputers and 4 or 5 Ohio Scientific, with a smattering of other micros--North Star, Apple

SOFTWARE:

The district invites anyone to use the software they have developed. They note, however, that a limitation may be the HP Basic language.

PERSONNEL:

Staff are self-trained. They started on HP and graduated to micros. Response to the use of computers has been favorable because staff have recognized the importance of computers.

COST:

The project has been funded through the district and a Title I grant.

RECOMMENDATIONS/COMMENTS:

1. Use of computers is effective for remedial education if skills are broken down to the lowest level and a program is develop which builds upon those skills.

2. CAI works if students are placed in the program for a reasonable period of time.

3. Teachers must be well organized when using the program.

4. The district encourages others interested in using the program to wait 2 or 3 years before they develop their own systems.

5. New goals for the district include: teachers evaluating their work on computer and teachers using CMI.

6. At present, the project's documentation is poor; it was not designed for publication. Therefore, interested parties are encouraged to observe the system, and if they have an HP system, they can get a copy of Medford's tape.

EDUCATIONALLY DISADVANTAGED (TITLE I) PROJECT: MOTI LAB

CONTACT PERSON: Michael Grice
Ockley Green Elementary School
531 S.E. 14th Street
Portland, Oregon 97214
(503) 232-9134

DESCRIPTION OF PROJECT:

A computer-managed multi-media project designed by the Prescription Learning Company to remediate basic skill deficiencies in reading and math at Grades 6-8 was implemented at Ockley Green Elementary School in September 1981. Students scoring two years below grade level in reading and mathematics were selected to participate in the project. Students are first tested and then receive a written prescription via a computerized system for remediating specific skill deficiencies. Response to the project has been favorable, although problems have been noted with CCC (e.g., students become bored with the repetitiveness of stories). The district is presently considering developing a computer literacy project.

HARDWARE:

MOTI LAB: Student-management system is on a Pet CB/M 2001 with 2 disks and a printer

Computer Programming: 1 TRS-80 Mod I on which students can sign up for 15-minute time periods

SOFTWARE:

Software is multi-media oriented and multi-cultural. Its main limitation is that the actual content of the reading program is very neutral; it could be much more informational.

PERSONNEL:

Training for the MOTI LAB, including programming, was provided by the company. Additional training was necessary for the CCC system. Initially there was some jealousy among teachers toward MOTI LAB teachers because of the Lab's popularity with students. However, this has dissipated.

COST:

The project was funded through a Title I grant.

RECOMMENDATIONS/COMMENTS:

1. Micro labs provide motivation for staff and students, thereby enhancing the school image.
2. The human element is as important as the hardware/software concerns.
3. Programming is more valuable than CAI, although the quality of CAI is improving.
4. Machines are not culturally biased.
5. The project is recommended for upgrading reading and math skills and for computing skills. It is essential for the school to have its "computer act" together.
6. Principals need to be taught about micros.
7. Media centers should subscribe to computer education journals.
8. Research on minority children's response to computers is encouraged.

CONFERENCE CONTACTS

Name/Address	Telephone

Resource List

RESOURCE LIST

I. Printed Materials

A. Computer Education Magazines
Classroom Computer News
Computing Teacher
Electronic Learning
Electronic Teaching
T.H.E. Journal
AEDS Journal
AEDS Monitor

B. Journals abstracted in Microcomputer Index: a subject index covering over 1,250 microcomputer magazine articles, including abstracts; published quarterly; online version that can be accessed by a terminal using a phone line also available. Asterisked (*) journals contained articles in 1981 specifically relating to education.

80 Microcomputing*
Apple Orchard
Byte*
Call A.P.P.L.E.
Compute*
Creative Computing*
Dr. Dobb's Journal*
Info World*
Interface Age*
Kilobaud Microcomputing*
Micro*
Nibble
On Computing*
Personal Computing*
Recreational Computing*
Micro
Softside*
Sync

C. Journals abstracted in Exceptional Child Education Resources that contained articles (1980-81) relating to the use of computers in educational settings:

American Annals of the Deaf
Special Education: Forward Trends
Journal of Special Education Technology
G/C/T
Australian Journal of Developmental Disabilities
American Journal of Mental Deficiency
Journal of Learning Disabilities
Educational and Psychological Measurement
Mental Retardation
Teacher Education and Special Education
Education Unlimited
Gifted Child Quarterly
Child Welfare
Social Work
School Shop

D. Journals abstracted in *Current Index to Journals in Education* (CIJE) that contained articles (1980-81) relating to the use of computers in educational settings:

Educational Computer Magazine
Business Education Forum
School Library Journal
Journal of Educational Technology Systems
Information Processing and Management
NASPA Journal
Media and Methods
Reading Research Quarterly
Educational Leadership
Foreign Language Annals
Educational Technology
Economics of Education Review
Training and Development Journal
Voc Ed
Exceptional Child
Mathematics Teacher
Journal of Educational Review

E. Additional journals containing articles relating to the use of computers in educational settings:

Cloud Magazine
Computerworld
Intelligent Machines Journal
MACUL Journal
Minicomputer News
North Star Newsletter
PET Paper
PET User Notes
Rainbow
TRS-80 Monthly Newsletter
Instructional Innovator
TRS-80 Software Exchange
TRS-80 User Notes
TRS-80 Users Group Newsletter
User Notes: 6502
Viper
80-US Journal
99'er
5100 User Notes
ACCESS: Microcomputers in Libraries
Small Computers in Libraries Newsletter

II. Agencies and Associations

A. State-wide organizations
State Departments of Education
Universities and Colleges

B. Nation-wide organizations

Microcomputer Software and Information for Teachers (MICROSIFT) (K-12)
Northwest Regional Educational Laboratory
300 SW 6th
Portland, Oregon 97204
(503) 248-6800

Association for Educational Data Systems (AEDS)
1201 16th Street, N.W.
Washington, D.C. 20036
(202) 833-4100

Project Local (Programmed Instruction)
200 Nahatan Street
Westwood, Massachusetts 02090
(617) 326-3050

Association for Development of Computer-Based Instructional Systems (Programmed Instruction) (ADCIS)
Computer Center
Western Washington University
Bellingham, Washington 98225
(206) 676-2860

National Consortium for Computer-Based Music Instruction (Programmed Instruction) (NCCBMI)
School of Music
University of Illinois
Urbana, Illinois 61801
(217) 333-0675

Association of Computer Users (Information Processing) (ACU)
P.O. Box 9003
Boulder, Colorado 80301
(303) 499-1722

Minicomputer Users Interest Group (Information Processing) (MUIG)
Department of Computer Science and Statistics
California Polytechnic State University
San Luis Obispo, California 93407
(805) 546-2824

Special Interest Group for Computer Uses in Education
(Instructional Development) (SIGCUE)
c/o Association for Computer Machinery
1133 Avenue of the Americas
New York, New York 10036
(212) 265-6300

The National Center for Research in Vocational Education
(publishes a mini-list of resources for microcomputers
in education)
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210
(800) 848-4815 or (614) 486-3655

CONDUIT (Hier Education)
P.O. Box 388
University of Iowa
Iowa City, Iowa 52244
(319) 353-5789

Computertown, USA.
P.O. Box E
Menlo Park, California 94025
(415) 327-0541

Association for Computing Machinery (ACM)
1133 Avenue of the Americas
New York, New York 10036
(212) 265-6300

International Council for Computers in Education (ICCE)
Department of Computer and Information Science
University of Oregon
Eugene, Oregon 97403
(503) 686-4408

Minnesota Education Computing Consortium (MECC)
2520 Broadway Drive
St. Paul, Minnesota 55113
(612) 376-1122

Society for Applied Learning Technology (SALT)
50 Culpepper Street
Warrenton, Virginia 22186
(703) 347-0055

Technical Education Research Centers (TERC)
Computer Resource Center
8 Eliot Street
Cambridge, Massachusetts 02138
(617) 547-3890

C. User's Groups

Apple for the Teacher (National Apple Computer)
5848 Riddio Street
Citrus Heights, California 95610

Apple Cart
23 Van Buren Street
Dayton, Ohio 45402

Keystone Apple Core (TRS-80 User's Group)
4644 Carlisle Pike
Mechanicsburg, Pennsylvania 17055

Pittsburgh Area Computer Club
400 Smithfield Street
Pittsburgh, Pennsylvania 15222

Pennsylvania Area Computer Society
(Apple, Pet, Radio Shack)
LaSalle College
Philadelphia, Pennsylvania 19142

Philadelphia School District (Apple User's Group)
Philadelphia School District
Parkway at 21st Street
Philadelphia, Pennsylvania 19103

Computer-Using Educators (CUE)
Independence High School--Computer Center
1776 Education Park Drive
San Jose, California 95133

Call Apple
(206) 271-6939

III. Computerized Information Utilities (computer networks that provide 1) access to a data base, e.g., ERIC and 2) computer (software) programs that may be ordered and delivered directly over phone lines)

QUBE
Leo Murray, Vice President of Public Affairs
75 Rockefeller Plaza
New York, New York 10019
widely-publicized, two-way cable TV station that offers normal cable TV, pay TV and local channels with some interactive programs

VIEWDATA
Viewdata Corporation of America
One Hefield Plaza
Miami, Florida 00101
a type of interactive text service

Teletext
John Carey
New York University Alternate Media Center
144 Bleeker Street
New York, New York
a constant stream of text and pictures broadcast over a TV station, each page coded with pre-selected keywords

CBBS
Craig Vaughan
Peripherals Unlimited
3450 E. Spring Street, Suite 206
Long Beach, California 90806

PCNET (Personal Computer NETwork)
People's Computer Company
Menlo Park, California

The Source
Computing Corporation of America (TCA)
1616 Anderson Road
McLean, Virginia 22101
the first home-terminal consumer information network in America

Micronet
Personal Computing Division
CompuServe, Inc.
5000 Arlington Centre Blvd.
Columbus, Ohio 43220
a home-terminal computer network, piggybacking off the CompuServe time-sharing company. Micronet concentrates on business programs, file editing and electronic mail

Electronic Information Exchange (EIES)
Anita Graziano
Computerized Conferencing and Communications Center
New Jersey Institute of Technology
323 High Street
Newark, New Jersey 07102
a nationwide community of about 1,000 members, divided into groups devoted to specific topics, e.g., Technology for the Handicapped, General Systems Theory

PLATO
Control Data Corporation
P.O. Box 0
Minneapolis, Minnesota 55440
computerized instruction program

Panalog
Ed Housman
GTE Laboratories
40 Sylvan Road
Waltham, Massachusetts 02154
an informal community of information
scientists, students and researchers in
technology for the deaf

IV. 8-Bit Microcomputer Software for Educational Administration Preface

The following represents a reasonably comprehensive list of the available software for the educational administrator. Many schools and districts are doing their own programming and implementation which is not being published. This field is beginning to grow very quickly, so this list is not claimed to be complete.

Education-Specific Software

A. Charles Mann & Associates (APPLE II 48k)
7594 San Remo Trail
Yucca, California 92284

1. Personal text processor
   - Administrative aids
   - Teacher
   - $65.95
   - 3.2
   - This program aids the school's secretary in preparing the school correspondence.
2. Grading systems programs 1
   - Administrative aids
   - Teacher
   - $199.95
   - 3.2
   - Helps teachers and administrators keep track of grades, cumulative averages and school credits.
3. The class scheduling program
   - Administrative aids
   - Teacher
   - $25.00
   - 3.2
   - This allows the user to perform a number of functions involved in class scheduling (including courses available).

4. Grading systems programs II
    - Administrative aids
    - Teacher
    - $249.95
    - 3.2
    - This program is a combination of the "grading systems program I" and a light pen which minimizes teacher keyboard entry.

B. Microdynamics Educational Systems, Inc.
2360 SW 170th
Beaverton, Oregon 97005

1. Various educational templates/modules are available for the DB Master (see part II)

C. Management Information Technology in Education (MITIE)
Jim Rose
School of Education
University of Colorado
Boulder, Colorado 80309

1. Enrollment projections by survival ratio method
2. Logistics curve forecasting

D. Data Processing Consultants
2405 San Pedro N.E.
Albuquerque, New Mexico 87110

1. Immunization package
    - 3.2
    - Retains personal data on all students as well as dates and status for up to six immunizations. Calculates next date for shot and prints a report.

E. Monument Computer Service
Village Data Centre
P.O. Box 603
Joshua Tree, California 92252

1. Assistant principal
    - $500.00
    - 3.2/AS
    - This package provides total control of class rosters, student master records, student schedules, teacher assignments and grade reporting.

F. Bell & Howell
7100 McCormick Road
Chicago, Illinois 60645

1. Grade system
   - o $450.00
   - o 3.2/AS
   - o This is a comprehensive grading system that allows grades to be kept and stored for up to 600 students on one diskette.

G. JEM Research
Discovery Park
University of Victoria
P.O. Box 1700
Victoria, B.C., Canada V8W 2Y2

1. The Administrators' Apple Package
   - o $500.00
   - o 3.2/3.3
   - o The package consists of attendance, demographic and textbook systems. The package has a word processing capability which allows for personalized attendance letters to parents.

H. OMNICO Computer Associates, Inc.
3300 Buckeye Road
Atlanta, Georgia 30341

1. Registrar
   - o $650.00
   - o 3.2/
   - o This is a complex registration system for high schools

I. Bridger High School District
429 W. Park Avenue
Bridger, Montana 59014
(Carl Fox)

1. Very comprehensive small district or single high school series of software packages for TRS0-80
   State Validated material includes
   - o Financial management
   - o Student accounting, scheduling, etc.
   - o Staff accounting
   - o Miscellaneous (school calendar, sports data, etc.)

General Software of use in Educational Setting

A. Word Processing Systems

1. Every microcomputer manufacturer has at least one word processing system which they market for their machine. In addition, several others are available from independent producers which they will tell you about.

B. Specialized Word Processing

- o Catalog writer
- o Business education administrative aids
- o Junior/senior teacher
- o Cook's Computer Company, 1905 Bailey Drive, Marshalltown, IA 50158
- o $19.95
- o 3.2
- o This is a word processing system designed to produce a descriptive catalogue

C. Decision-Making Aids

1. Electronic work sheet type

   Visicalc
   Personal Software, Inc.
   592 Wedden Drive
   Sunnyvale, CA 94086

   DB Master
   Stoneware Microcomputer Products
   1930 Fourth Street
   San Rafael, CA 94901

2. Desktop Plan
   Personal Software, Inc.
   (See above)

3. Visiplot, Visitrend
   Personal Software, Inc.
   (See above)

D. Accounting Packages

1. The Controller
   - o business education
   - o teacher
   - o Apple Computer, Inc.
   - o local dealer
   - o 3.2
   - o This is a comprehensive accounting system

E. Data Base Management Systems

1. Data Factory
   - o Microlab
     3218 Skokie Valley Rd.
     Highland Park, Illinois 60035

2. Visifile
    o Personal Software
      592 Wedden Drive
      Sunnyvale, California 94086

3. DB Master
    o Stoneware Microcomputer Products
      1930 Fourth St.
      San Rafael, California 94901

4. Database Manager-1 (CROMEMCO)
    o Condor Computer Corporation
      3989 Research Park Drive
      P.O. Box 8318
      Ann Arbor, Michigan 48107

5. Global
    o Global Parameters
      1505 Ocean Ave.
      Brooklyn, New York 11230

APPENDIX

COMPUTERS IN THE CLASSROOM

COMPUTERS IN THE CLASSROOM

Northwest
Regional
Educational
Laboratory

COMPUTERS IN THE CLASSROOM

Written and Printed by:

Northwest Regional Educational Laboratory
300 S.W. Sixth Avenue
Portland, Oregon 97204
Telephone (503) 248-6800

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The Portland Public School District
Portland, Oregon

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Judith B. Edwards, Director

Antoinette S. Ellis, Author

Jerilyn L. Marler, Editor

Preface

This document was prepared by the staff of the Computer Technology Program of the Northwest Regional Educational Laboratory persuant to a contract with the Portland Public Schools, Oregon. It is a statement of the scope of instructional computing and a definition of its components for teachers and administrators to use as a framework for further reading and discussion. This document is not a definition officially approved by the Portland Public Schools. It represents the opinion of the staff of the Computer Technology Program.

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Teaching About Computers

Student reaction to computers in school is almost universally positive. Even those who are initially threatened by the computer quickly become intrigued.

Christine Doerr
Microcomputers and the 3 R's

Elementary and secondary students typically study the computer in four major coursework areas, which are described in the following pages. These areas provide a reasonable framework in which to envision present and future computer-based instruction. It may, however, be organized somewhat differently in special cases and, in the future, new areas may develop to such an extent that they merit separate course content and definition.

Computer Literacy

While the content of other computer courses aims at a more in-depth comprehension of and experience with the computer as a machine and tool, the computer literacy course focuses on the computer as an increasingly important technology influencing our private and public life. The computer is identified as contributing to the solution of social and economic problems and in creating the environment for people to create new problems. Although limitations on hardware capabilities are decreasing rapidly, limitations of people to deal with the computer are not dropping as quickly.

As defined by the Oregon Commission on Computers in Education, computer literacy involves the achievement of:

> ...awareness, attitudes, and knowledge necessary to understand the effects of the computer on society. It is essential that everyone be cognizant of the capabilities and limitations of the computer and be attuned to the social, vocational and governmental implications of the increasingly widespread utilization of computers.

Hansen, Klassen et al. in their article "Computer Literacy Courses" (AEDS Monitor, October, 1979, p. 29-30), describe computer literacy courses currently taught as varying widely in content, often including elements of programming, computer operations, etc. But as computer courses become articulated in the modern curriculum, "literacy" courses should generally focus on broader concerns:

- What is the student's orientation to computers?
- What is the present and future role of the computer?

- What are the capabilities and limitations of computers?

- What implications do computers have for society?

Orientation may typically include the history of computing, an overview of computer parts and how they work, and a general introduction to how people communicate with and control computers. Some exposure to computers in hands-on experience should be included. Present and future role discussions may include an introduction to the uses of computers in government, business, medicine and science, education and information centers, and future visions of innovative, expanded and newly created roles for hardware and software. Capabilities and limitations of computers may focus on present and potential characteristics of speed, accuracy, access and storage dimensions, versatility, compatibility as well as its various technical limits and limitations. The spectrum of implications which computers hold for society in the present and future may include looking at its positive and negative impact on individuals, groups, the economy, education, employment, and so forth.

A special burden of "currency" is implied for the computer literacy course which, by its nature, addresses the broadest school audience with a generalized introduction to the computer. Instructors of this course will be required to keep its content current with technical innovations and their impact and implications for society.

Instructional objectives may also be met by incorporating them in other established courses at a variety of grade levels. In this alternative format, the previous comments on content still apply, but simple concepts may be covered early in the student's school life. Requisite mathematics may be handled in the math curriculum, electronics in the science curriculum, and social impact in the social studies curriculum. The useful applications of computers may be exemplified by using the computer as a matter of course whenever it is useful in school work for simulation, problem-solving and other techniques.

Computer Science

The definition of computer science provided in Computer Applications in Instruction, by Judith B. Edwards et al., continues to apply:

> Courses in computer science usually include a practical introduction to the computer as a machine, giving attention to the basics of how it operates, how to run programs on it, and how to write programs. These courses may be given independently of mathematics, science, or business courses, or they may be associated with a related discipline in order to offer students more specialized and useful exposure to computer programming.

The aim of computer science is, therefore, the study of the machine and related technology, including programming the computer to achieve specific ends. The study of computer science and programming has been successfully included in the curriculum at any level of education, beginning as early as grade one.

The focus of computer science at the elementary and secondary levels will increasingly be on the small, accessible microcomputer as it becomes more available. The larger and more complex machines involved in time-sharing computing—where the actual mainframe computer is usually inaccessibly located at a distance—may continue to be the focus of computer science at the college levels. Pre-college computer programming will involve varying degrees of programming skills for problem-solving and/or data processing, depending on the discipline(s) with which the course is associated. Although the programming language taught will usually be a version of the general purpose BASIC, some micros now have PASCAL, COBOL, FORTRAN and other language options which may be preferred in specific situations.

Computer Languages

Computer languages are not as complex as a natural language like English, but there are parallels. Computers accept words and symbols as commands to perform certain functions. It may be as simple as multiplying two numbers which requires very few language words (programming steps). Or the desired outcome may involve hundreds, even thousands of steps. Computer languages have a rigorous vocabulary and syntax. A missing comma or misspelled word can thwart an entire program.

A programming language is converted by the computer into "machine language"—electronic impulses across circuit boards. It is possible to by-pass a programming language and communicate with the computer directly through machine language. It is much more difficult to learn, but when understood provides greater flexibility for program creation and manipulation.

The range of computer languages being included in elementary and secondary programming instruction is expanding to greater contact with and understanding of the computer itself. Some programming languages serve a general purpose and are relatively English-like: BASIC, COBOL, FORTRAN and so forth. These are the usual focus at pre-college levels and provide for varying degrees of programming proficiency. Students can be introduced to some of the more specialized languages such as PASCAL or even LOGO which may be especially suitable in specific situations where programming is being taught.

However, as microcomputers become more and more available in the school setting and so provide personal control, an increasing number of students will have the opportunity to develop abilities in machine language as well.

Classes in computer languages may aim at various goals, including the manipulation of the computer itself (as in the development of system software), the programming of games, simulations or graphics, and the creation of problem-solving programs for various uses.

Vocational/Pre-Professional Skills

Traditional courses teaching vocational or pre-professional skills include practical training in keypunching (the preparation of data on keypunched cards), terminal operation, computer operation and programming for data processing functions. This focus will continue to be important due to the continued prevelance of data processing operations in business, government and sciences. Therefore, the terms "vocational or pre-professional skills" will necessarily include these training areas.

As the technology continues to change rapidly, however, modifications in traditional skills and entirely new skills will become a part of training programs. For example, keypunching will decline in importance as direct data entry becomes more common. Further, as the use of microcomputers spreads in business and government, special vocational training will begin to focus on the operation of microcomputers and their peripherals.

Teaching With Computers

When teachers first consider a computer in their classroom, they are gripped by an all-too-common fear—the fear of being replaced by a machine. On the contrary, the computer *by itself* can never be as effective as a human teacher; an alliance of the two, however, creates a powerful teaching force.

Christine Doerr
Microcomputers and the 3 R's

During the last decade, the uses of computers in instruction have multiplied to include a great variety of roles for the computer as an instructional instrument. The main modes of computer use defined below are: drill and practice, tutorial, simulation, problem-solving, and information retrieval. It is important to note that these descriptions are "working definitions" for the purpose of general conceptualizations. In practice the roles may overlap, combine or deviate from the typical patterns described here. Each of the roles also finds application across grade levels and curricular areas.

Drill and Practice

Drill and practice with the computer has particular value where specific facts need to be learned or specific skills need to be developed, such as in arithmetic, spelling, history, reading, languages and the sciences.

As defined simply by Edwards et al., drill and practice

> ...implies that the computer can act as a drillmaster. Students first develop a skill or acquire some factual knowledge--without the computer...they then use the computer to review and practice these skills and concepts.

The special utility of the computer in this educational role is described in the AEDS Journal special issue, "Microcomputers: Their Selection and Application in Education":

> A student's tolerance (and need) for routine, repetitious practice may exceed an instructor's (or parent's) available time or patience.... Just the tireless patience of a computer makes drill and practice on such a medium valuable.

The drill and practice format is usually a basic computer-originated question (or problem) and student-entered answer format. Within this general design, a great variety of methods are used for indicating correct or incorrect responses, providing cues or hints, tracking students along a gradient of problems according to answers, grading performance, and so forth. This differs from the tutorial mode in that drill and practice imparts no new skill or information.

A significant advantage of using the computer as a drill master is its capability of simultaneously acting as a teacher's aide by keeping detailed records of student performances. This role, however, will be considered a specific function of the computer in "managing instruction," discussed below.

The introduction of microcomputers will expand this use of computers across the curriculum and grades, including special students who can benefit from patiently conducted drill. Most drill and practice programs do not require storage capabilities in excess of what micros can typically handle. The small size of micros makes them uniquely accessible to children in the primary grades where drill is daily a part of the instructional process.

Tutorial

In the tutorial mode approach the computer acts as a tutor, providing new factual information and engaging the student in a question-and-answer dialog about that information. The computer can be programmed to guide the student into integration of information and discovery, and in routing the student through helpful additional or remedial information on which he or she can be further engaged in dialog. While drill and practice typically discriminates only right answers from wrong, tutorials can be programmed to deal with any conceivable response, which heightens the interactive quality for the student. The assumption in tutorial mode is that the algorithm for teaching a topic is well defined and can be programmed for a computer.

Ordinarily a great deal more memory and/or storage capability is required than in simple drill and practice, making the size of the new smaller micros (e.g., 8K) a possible limiting factor for this role in today's classroom. However, with disk or tape storage capabilities relatively unlimited for most micros, even unusually large tutorial programs may be fitted to the smaller micros.

Simulation (modeling, gaming, scenarios)

Simulation applications are those which operate on and present experience with a model of physical or social situations. The model simplifies the situation being presented. It can be organized as a pedagogical scenario or as a game with which the student interacts in order to accomplish certain goals (reach the end, win, survive, etc.). This mode may be the most popular among students and teachers alike as it can provide exceptional motivation and interest. Simulation is often responsible for providing the only practical, safe or possible experience with a given situation under study. For example, studies of hereditary characteristic transfer or radioactivity which, for reasons of time and/or safety cannot be conducted in the classroom, can be simulated by a computer program.

The difference between simulations and pure games may often be obscure. In an ecology simulation, for example, where two life forms compete for survival, the goal of surviving may easily translate into "winning" and the competition be experienced as a game. For purposes of distinction it may be useful to designate as a simulation any computer application which presents experiences with instructive information by modeling "real world" situations. When the gaming mode is highly visible, as in an economics simulation where the student saves the country from economic collapse by strategic decisions about resources and policies, the application may be classified as a "simulation-game." The computer program which presents non-instructional information (however interesting or applicable to real work situations) in a game mode may qualify as simply a "game." It must be kept in mind that pure games are sometimes very effective in classroom use, for example, in introducing computer use, in promoting cooperative behaviors, and so forth.

Problem-Solving

The role of the computer in problem-solving may be divided into three essential uses: using the computer (1) as a calculator, (2) as a complex problem-solving device, and (3) as a vehicle for teaching problem-solving.

In this first role as a calculator, the computer offers speed and accuracy in performing the kinds of complex calculations often required in mathematics, science, and business courses where the solving methods are not the central focus. Affordable and convenient hand-held calculators offer just this problem-solving capability, but in a much more limited fashion. They generally do not provide a print-out of calculations, and the memory capability is markedly inferior to that of a computer. Computers offer large display capacity or hard copy on which to track and trace calculational work, often an important feature for the student generating or using solutions to complex problems. The advent of the microcomputer brings the power of much more complex calculations into use by students at far less cost than previous time-sharing computing required.

In the second role as a complex problem-solving device, the computer is used not simply as a calculator but is employed as a tool for solving complex (multi-dimensional) problems and providing large amounts of otherwise inaccessible information. Problem-solving programs do not deliver instruction or correction; they simply allow the student to enter all the data needed to solve the problem(s). The computer then performs all manipulations and provides the answer. For example, using a typical program designed to solve problems concerning payments on long-term loans, the student might be directed by the program to enter information on amount borrowed, interest rate, and term of loan. The computer would then perform all necessary manipulations. A printout (or display) could provide an entire payment picture from a schedule of outstanding balances at the beginning of the payment periods to period-ending interest and principal payments due. Or a simple problem-solving program which will factor trinomials may direct the student to enter values for x, y, and z after which it will perform the necessary manipulations and printout or display the factors. Such programs are designed to solve many problems of the same kind quickly, one after the other.

The third problem-solving role, using the computer as a vehicle to teach problem-solving, centers on students writing programs to solve a problem. According to Edwards *et al.*, the use of computers for teaching problem-solving was, in 1975, "probably the most popular instructional use of the computer to date, since typically fewer curriculum materials are required and prewritten programs are not needed." This situation appears to be unchanged at the beginning of the 1980's. Computer-based curricular materials are still limited, especially in schools which are just beginning to use computers in instruction and have no experience in collecting, testing and using instructional programs. As computer-based materials become more readily available, the unique capability of the computer in the area of teaching problem-solving will continue to be one of the technology's strongest educational tools.

Teaching problem-solving through programming centers on the students' grasping programming methodology and a programming language sufficiently to design (program) the steps that will produce the solution to a problem. It demands logic, precision and an understanding of the concept being programmed. Development of these skills is thereby taught and encouraged. The computer is being used successfully in this way as early as grade one, where just a few skills in flowcharting and programming can equip children to program problem-solutions with clarity and considerable enthusiasm. At higher levels, instruction in problem-solving through programming can become highly technical and complex. It can begin to encompass such domains as game development, data management, industrial drawing using specialized graphics, and so forth.

As with the computer roles described previously, the application of the computer in problem-solving can be used effectively in many different curricular areas. The relevant requirement is simply that some problem-solving be taught or involved in the successful study of the subject. This, of course, makes the major disciplines of mathematics, sciences and business especially appropriate at all levels for these computer uses.

Information Storage and Retrieval

This mode of use involves a data base and the use of a program to summarize, compare, analyze and otherwise manipulate the data stored in it. A major application is the collection and analysis of data through surveys or questionnaires. Another is the collection of historic data about a community or other entity from records, to create a "picture" or "model" of that community. A good retrieval program would then allow students to pose questions about the nature of life in that community which could be answered by selecting relevant information.

Another major application in this classification is the use of large data bases for guidance and counseling. Several such systems exist which enable students, teachers and parents to quickly search for available opportunities and prerequisites for various careers, and the opportunities for post-secondary education. The databases are usually regional or national in scope and can be searched in a few minutes according to a wide range of criteria. The time savings and the comprehensive nature of the information are very valuable features.

Computer As Teacher Support

> Teachers are freed from the negative roles of "judges," and they are free to expand their roles as mentors; yet at times the innovative student makes the breakthrough, providing the teacher with one of the great rewards in this profession.
>
> Christine Doerr
> *Microcomputers and the 3 R's*

While the computer offers a wide range of educational capacities—as a subject of study and as a vehicle of instruction—the technology's capabilities can be of immense value as an aide to the teacher as well. The computer provides expanded resources for designing, teaching and analyzing instruction and performance thereby increasing efficiency and success in the classroom. The four general categories described below encompass the major services computers can perform for the teacher.

Goal/Objective Setting

Goal or objective setting involves establishing evaluation criteria and a continual reorganization of quantities of information and regarding students, teaching materials, scheduling, etc. The computer can provide teacher support in this essential area by providing storage and retrieval capability and analysis of data where time had often prohibited such preparatory work.

Evaluation/Assessment

The aim of evaluation/assessment is described in the TIES manual on "Instructional Management Support," as being

> ...to determine how the student performs in relation to the goals and/or objectives, and assessing the instructional procedures and tools used. This may lead to a redefinition or restatement of goals and/or objectives or may result in a change in teaching techniques and/or strategies.

Computer support of evaluation/assessment activities includes test item generation, storage and retrieval, and scoring and analysis of tests. This may offer the busy teacher important information and insights for which time may not otherwise be available. Computers can further supplement the evaluation/assessment activity by generating reports of student progress, status, grades and summaries of data.

Diagnosis

Greater stress is increasingly being placed on diagnosis and successful remediation in situations

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of learning difficulty or failure. Computers can play an important role in assisting the teacher to develop a complete student profile of strengths, weaknesses and other variables necessary for analysis of the learning situation and diagnosis of student needs. The computer offers storage and retrieval of significant historical records as well as comparative data from norms testing. Diagnostic tests can be generated for use in more definitive analysis; the quantitative aspects of analysis can also be handled by the computer. Summaries and reports involved in effective diagnosis therefore become more accessible to educators.

Planning/Prescribing

The process of planning and prescribing is partially defined in the TIES manual cited above as that step in "determining the educational experiences and settings necessary to meet the instructional needs." This involves the consideration of student diagnostic information as well as other available resources, strategies and activities. The computer can serve by:

- providing grouping and scheduling routines,
- storage and retrieval of relevant diagnostic data and instructional material references,
- generation of individual or group activity prescriptions for a designated time period such as an hour, day, or week.

The essence of planning and prescribing is determining which student should be placed with which teacher in what space and time with what resources to reach which objectives.

In addition to the aspects of computers in instructional management discussed above, other more general capabilities of the computer as a teacher's aide should be kept in mind:

- computer-based information storage and retrieval can play an important role in collection of materials for instructional presentation, which otherwise require time-consuming searches through files and libraries. Further, the storage and retrieval capability of computers has been effectively used for presenting career guidance information.
- materials generation is a capability of the computer which utilizes the computer's storage and retrieval power with its printing capability to create specialized computer-interactions, individualized worksheets, text materials and so forth. Such materials can be tailored to class or individual by the teacher. This capability may be combined with the evaluative, diagnostic and planning activities discussed above to produce an over-all individualization of instruction.

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APPENDIX

Glossary of Computer-Related Terms

Bit Pad	A rectangular electronic tablet which causes designs drawn on it with a special pen to be stored in coded form in a microcomputer for later display on the video screen (CRT).
CAI	Computer Assisted Instruction, usually encompassing drill and practice and tutorial applications of computers, but also used by some to include all instructional applications.
Cassette	A small plastic cartridge containing one-eighth-inch magnetic tape for use in cassette recorders.
CBE	Computer-Based Education, refers to all instructional applications of computers.
CMI	Computer Managed Instruction, refers to the use of computers to assist in the management of instructional activitives.
CRT	Cathode Ray Tube, a video display screen.
Data base	The collection of all data used and produced by a computer program. In large systems, data base analysis is usually concerned with large quantities of data stored in disk and tape files. Smaller microcomputer systems are more frequently concerned with data base allocations of available memory locations between the program and data storage areas. Also called data bank.
Data Entry	The task of storing data in a computer from a device such as a terminal or card reader.
Disk Drive	A mechanical and electronic device which stores and retrieves information from a disk.
Downloading	A procedure enabling the microcomputer to be used like a terminal when connected to a central time-sharing computer system. A program stored in the central computer can be transferred to the microcomputer and stored in the micro's memory. This program can then be saved by the microcomputer on its storage device (i.e., floppy disk) for later use. (Uploading is a transfer from micro to central system.)

Drill and Practice	A CAI program in which the computer acts as a drillmaster.
EPROM	Erasable Programmable Read Only Memory, which is like PROM except that it can be erased and reused.
Floppy Disk	A magnetic mass storage medium used to store programs and data not currently used by the micro. The floppy disks are so named because they are soft and bend easily. Typical classroom micros use a mini-floppy which is 5 1/4" in diameter, and stores about 100,000 alphabetic characters.
Game	A Computer simulation with a win/lose element; the student takes partial or total control of one side of the action.
Graphics	Facilities to provide computer output in the form of displays, drawings, and pictures.
Hardware	Physical equipment such as electronic, magnetic, and mechanical devices. Contrast with "software."
Joystick	A device frequently used with microcomputers to control the movement of figures in a display.
K	A metric designation meaning 1000, typically used in computer terminology to mean 1000 characters of storage. For example, a 16K micro refers to a microcomputer having space in RAM for approximately 16,000 characters of information.
Keypunching	The process by which original, or source data, is recorded in punch cards. The operator reads source documents and, by depressing keys on a keypunch machine, converts source document information into punched holes.
Line Printer	An output peripheral device that prints data one line at a time.
Magnetic Tape	A plastic tape having a magnetic surface for storing data in a code of magnetized spots. Data may be represented on tape using a six- or eight-bit coding structure.
Microcomputer	A computer based on a microprocessor; consists of the CPU, memory and input/output circuitry. Usually called a "micro."

Microcomputer System	Consists of the microcomputer plus additional peripherals such as video display devices, printers, and floppy disks.
Microprocessor	Central processing unit (CPU) contained on one chip; nicknamed a computer-on-a-chip.
MicroSIFT	Microcomputer Software and Information For Teachers, a clearinghouse for educational programs and information about microcomputers operated by the Northwest Regional Educational Laboratory, Portland, Oregon.
MODEM	An acronym for MOdulator-DEModulator. A device that permits the transmission of data over communication lines by changing the form of the data at one end so that it can be carried over the lines; another modem at the other end changes the data back to its original form so that it is acceptable to the machine (computer, etc.) at that end.
On-Line	A term describing equipment, devices, and persons that are in direct communication with the central processing unit of a computer. Equipment that is physically connected to the computer.
Operating System	An organized collection of software that controls the overall operations of a computer. The operating system does many basic operations that were performed by hardware in older machines, or that are common to many programs. It is available to the computer at all times by being held either in internal storage or on an auxiliary storage device. Abbreviated OS. A disk operating system is referred to as DOS.
Peripheral	Refers to devices attached to a computer which perform useful functions, such as printer, CRT, disk drive, bit pad.
Problem Solving	An instructional use of the computer in which the student learns about some aspect of the real world by writing or using a computer program to solve the problem.
Program	(1) A sequence of instructions that permits a computer to perform a particular task. (2) A plan to achieve a problem solution. (3) To design, write, and test one or more routines. (4) Loosely, a routine.

PROM.	Programmable Read Only Memory, which is programmed by special means other than the micro keyboard.
RAM	Random Access Memory. Used to store user programs; however, the contents are lost when the microcomputer's power is shut off.
RF Modulator.	A device needed to modify a standard television for use with a microcomputer. It, in effect, converts the monitor signal from the computer to the regular TV signal.
ROM	Read Only Memory. Contents of ROM are permanent and cannot be changed by the user. For most microcomputers, BASIC and the operating system reside in ROM.
RS 232 Serial Interface . .	Enables the microcomputer to exchange data with other computers or with peripherals such as printers.
Simulation.	A computer program based on a model which behaves like some portion of the real world.
Software.	A set of programs, procedures, routines, and documents associated with the operation of a computer system. Software is the name given to the programs that cause a computer to carry out particular operations. The software for a computer system may be classified as application programs and system programs. Contrast with "hardware."
Terminal.	(1) An input/output peripheral device that is on-line to the computer, but that is in a remote location: another room, another city, or another country. (2) A point at which information can enter or leave a communication network.
Time-sharing.	A method of operation in which a computer facility is shared by several users for different purposes at (apparently) the same time. Although the computer actually services each user in sequence, the high speed of the computer makes it appear that the users are all handled simultaneously.
Tutorial.	A CAI program in which the computer describes some concept or process and then engages the student in a question and answer dialog.